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FROM MASS PRODUCTION TO SCALE CUSTOMISATION

量產客制化

RESEARCH REPORT (TEXT VERSION)

Challenges & Opportunities for Hong Kong Industrial Design Professionals

香港工業設計專業的挑戰與機遇

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Abstract

The belief of manufacturing as mass production, in which raw materials are processed into finished products in large scales, is no longer the status quo in the industrial sector. The Fourth Industrial Revolution is here, bringing human civilisation to another height of evolution. From steam power to electricity, analog machines to digitalisation, the transformative power in Industry 4.0 is transforming every aspects of human lives, from production, consumption, communication, education, work, governance to business strategy and more.

What causes the paradigm shift can be mainly due to the rapid progression of technologies, and its impacts on user behaviors alter the expectations of consumer demands in the market. It has been over ten years since mass consumers adopted and immersed in mobile technologies. Almost everyone has a smartphone in their pocket now. It is no longer just a device for communication, it is also a device with instant accessibility to all information around the world, a device that has intelligence to assist human requests, a device that can track and monitor human activities, a multimedia device, a gaming centre, and more to be noted and to be seen.

Since the 1990s, in just a little under thirty years, people are globally connected through technologies, and now it is time for machines to be connected. This is happening in the industrial sector now, and this requires a fundamental change of mindsets and skill sets in which manufacturers and designers operate and thrive in this new industrial economy. It is neither about singular artefacts crafted by artisans nor the standardisation of products with mass production, it is about scale customisation - a production paradigm which combines the benefits of niche market production with the benefits of economies of scale in mass production.

With growing choices of product selections and hyper transparencies of information, generalisation of products will no longer meet consumer demands. Consumers will crave for more customised items specific to their needs, and this creates many pockets of niche markets, leading to segregation and fragmentation of product and service offerings. In order to satisfy this demand, the shift to scale customisation thus becomes imperative.

Technologies will continue to empower consumers to personalise their digital and physical settings, and this seamless integration of virtual and physical world will enable consumers to become part of the design/creation process. Tangible products with sensors and connectivity can be linked via platform-based services, extending the capabilities and capacities of what traditional products can offered as standalone. As technologies become an integrated part of the production, the businesses that can thrive and propel forward are those equipped with new tools, knowledge, and flexible scales.

Mass production will still be at its peak to satisfy the economies of scale, and it is not meant to be replaced in the short future. However, digitalisation has allowed manufacturing to explore new business modelling - decentralisation - where manufacturers can leverage smaller local production bodies distributed across various physical regions, while connected and synchronised digitally, to accomplish what manufacturing could not once achieve without centralising all machineries and assets in one physical location. This not only lowers the cost of entries and increases flexibilities of production, but it also brings a new dimension to manufacturing as a whole.

On the other hand, technological advancements have caused the market landscape to become far fiercer and more diluted than before. Competitions are no longer just within one sector. Speed to production in meeting constant changing consumer needs, and consumers' engagements have become far more critical than ever. Without transparencies to understand end users' needs, manufacturers will only be pushing products and services blindly to the market, wasting valuable time and investments.

Conventional methods and approaches are not going to yield the same values and returns. Products, which are traditionally viewed as tangible, can now be enabled by technologies to generate intangible values through the gathering of experiential data and virtualisation. It is not that the manufacturing sectors have never met such transformation in the past, it is different because product and service integration with technologies have become far more effective in production in this economic and technological shift.

Every industrial revolution marks a major turning point, influencing all parts of human progression. One key observation is that the first to second industrial revolution spanned over ten decades, and onwards to the third revolution had reduced to approximately seventy years of time. Most significant of all, the third to fourth only took place in about forty years. The world is changing faster and faster. From economies of scale to economies of scope, the Hong Kong industrial sector must be prepared for this global tide, and industrial designers must fully transform their mindsets to redefine their values and roles in this new paradigm.

This e-book, "From Mass Production to Scale Customisation", will highlight design and manufacturing principles and methodologies adopted from past to present, along with research findings conducted with 70 local experts, industrialists and industrial designers. Every piece of information has been carefully considered to portray the essence of scale customisation in the Fourth industrial revolution.

Contents

1. Research Overview

1.1 Research Aim

Nowadays Hong Kong industrial design professionals (HKIDP) are facing the predicament of a double-sided sword. Not only do the HKIDP own branded products but the stakeholders, including the manufacturers, in-house industrial design practitioners, have been tolerating to lose either the market opportunities or overcome the supply challenges. The research study aims to investigate how the concept of scale customisation[1] of industry 4.0 may narrow the gap between the growth of evolving market demand for variable styles and the requirements of higher minimum order quantities from manufacturers.

According to a survey published in 2014 by the Hong Kong Federation of Design Associations, there are 88,571 designers in the industry. The total figure represents about 2.3% of total employment in Hong Kong. They get an equal opportunity to participate in any commercial activities of industrial design, when Hong Kong is the sixth largest trading partner in merchandise trade and the fourth largest in services trade of Association of Southeast Asian Nations (ASEAN) for 2016. The recent signing of the ASEAN Free Trade Agreement (FTA) and related Investment Agreement sees the indispensable role for HKIDP to be engaged in the initial planning of manufacturing processes.

Hong Kong has been ranked high in the 2015 Global Creativity Index, or GCI. The GCI is a broad-based measure for advanced economic growth and sustainable prosperity based on the 3Ts of economic development—talent, technology, and tolerance.

That ranking could change, thanks to the Hong Kong government's emphasis on creativity and design thinking. In the Chief Executive's 2017 Policy Address, the government acknowledges design professionals' success in enhancing the competitiveness of their clients, through branding and value addition. The government plans to take it one step further by collaborating with design professionals to transform creativity and design thinking into a "problem-solving" tool in public administration and business operation.

Hong Kong industrial design professionals have been trained to serve the industry and manufacturers, especially for mass production. With the industrial revolution well into the fourth stage (Industry 4.0), mass production is no longer the only option. In the emergence of scale customisation, a disconnection between the industrial design professionals' traditional knowledge and the demands of its consumers occurs.

To keep up with the industrial wave, scores of Hong Kong entities have organised activities to enrich the knowledge of the manufacturing industry. Industrial design in Hong Kong, meanwhile, still lags behind in terms of adapting to scale customisation. This research study constitutes part of

[1] For more details on scale customisation being included in mass customisation, please see Dan Ostroff's "Ted Talk – Scale Customization – The Future of Manufacturing"; on smart customisation, please check Olivier, Keith et. al., "Smart Customization: profitable Growth Through Tailored Business Streams", on large-scale product customisation, J.P. Gownder's "Why Large-Scale Product Customization Is Finally Viable for Business". Also, similar initiatives of industry 4.0 are including but not limited to Industrial Internet, Manufacturing 2025, and Made in China 2025.

the capacity building project for Hong Kong Industrial Design Professionals (HKIDP), aiming to disseminate related new knowledge about scale customisation of Industry 4.0 and also to examine the current landscape of scale customisation.

This research study will address the gap in knowledge for HKIDP. It is done through research and thematic workshops on 30 June 2018, a pavilion with a series of seminars during DesignInspire in December (part of the Business of Design Week 2018) and the dissemination of knowledge through an e-publication of this report as a guide. The objective is for HKIDP to get first-hand knowledge from international and local experts on the industry as a whole, on the market, and most importantly on the evolving role of HKIDP toward capacity building for scale customisation.

According to a survey published in 2014 by the Hong Kong Federation of Design Associations, there are 88,571 designers in the industry. The total figure represents about 2.3% of total employment in Hong Kong.

The HKIDP has been trained to serve the industry and manufacturers, especially for mass production. Traditional training of HKIDP covers material, process of fabrication by machines. Industrial design is more than just designing products or human-oriented problem solving. Rather, with the emergence of Industry 4.0 it has evolved into an ideology on innovative design thinking. HKIDP shall acquire knowledge of Industry 4.0 which allows them to design the customers' experience starting from the fuzzy-front-end of the process.
Industry 4.0 is the current trend of automation and data exchange in manufacturing technologies. Revived at the Hannover Fair 2011, followed by the recommendations of the Working Group on Industry 4.0 to the German federal government, it is, in an essence, the creation of the "smart factory."

Similar to mass customisation, the straightforward definition of scale customisation was "producing goods and services to meet individual customer's needs with near mass production efficiency" by Stan Davis (1987). The equipment allows low volume production and prototyping, while the feasibility of mass / scale customisation always entails the mindset of the leader, management and knowledge workers.

Despite its ability to shorten a product lifecycle while refining its quality and demands, Industry 4.0 does have its drawbacks. In Hong Kong, designer professionals are evolving in other development rather than the industrial movement. It reflects a general lack of support for the changes from stakeholders. One factor that contributes to this could also be the absence of appropriate skillset within the design industry, which in turn points to the provision of and financial support for Continuing Professional Development (CPD) that go missing.

This is especially true for Hong Kong, as most of its industrial design professionals are trained with mass production in mind, a time when digital technologies were unheard of and the only technologies involved were machinery and equipment. Moreover, some newly trained HKIDP tend to be artisanal. A disconnect between HKIDP's traditional knowledge and the demands of its consumers incurs. Out of touch with both the industry and the market, in time this could result in the marginalistion of traditionally well-trained and valuable design workforce. There lies the importance of prolonged professional knowledge enhancement such as Industry 4.0 and digital technologies for these designers.

Hong Kong has close ties with the Association of Southeast Asian Nations (ASEAN). It is ASEAN's sixth largest merchandising partner, its second largest trading partner in merchandise trade and

the fourth largest in services trade for 2016. The recent signing of the ASEAN Free Trade Agreement (FTA) and related Investment Agreement sees the indispensable role for HKIDP to be engaged in the initial planning of manufacturing processes.

Hong Kong is ranked 21st in the 2015 Global Creativity Index, or GCI. The GCI is a broad-based measure for advanced economic growth and sustainable prosperity based on the 3Ts of economic development—talent, technology, and tolerance.

That ranking could change, thanks to the Hong Kong government's emphasis on creativity and design thinking. In the Chief Executive's 2017 Policy Address, the government acknowledges design professionals' success in enhancing the competitiveness of their clients, through branding and value addition. The government plans to take it one step further by collaborating with design professionals to transform creativity and design thinking into a "problem-solving" tool in public administration and business operation.

To keep up with the industrial waves, a number of Hong Kong entities have organised conferences and seminars to cater to the Industry 4.0 initiatives. For example, the Hong Kong Productivity Council recently unveiled the "Smart Industry One", an automated industrial demonstration centre in Hong Kong that is geared more towards the manufacturing industry. As an aside, the centre also included a "Cyber Physical Production System" to demonstrate the features of scale customisation.

While the Smart Industry One is a good effort to promote industrial automation in Hong Kong, there is still a significant gap in terms of knowledge and the market. In view of the capacity of scale customisation and the Hong Kong government's push on creativity and design thinking, the launch of this research offers tailor-made learning opportunities for HKIDP.

1.2 Research Methodology and Scope

The investigation on how the concept of scale customisation of industry 4.0 may narrow the gap between the growth of evolving market demand for variable styles and the requirements of higher minimum order quantities from manufacturers triggers a series of research questions:

- To what extent the HKIDP and the Hong Kong manufacturers understand and use scale customisation of industry 4.0?
- How do HKIDP and Hong Kong manufacturers perceive industrial design?
- How do the different perceptions facilitate or hinder the collaboration between HKIDP and Hong Kong manufacturers, if any?
- What is the best practice of collaboration between HKIDP and Hong Kong manufacturers?

The research comprises (a) literature review / secondary research of scale customisation, Industry 4.0 and equivalent initiatives or movements, and related knowledge of HKIPD; (b) four series of interviews, including 15 experts of Industry 4.0, 17 scale customisation specialists [and industrialists], 18 in-house industrial designers and 20 non-in-house industrial designers in Hong Kong; (c) three sessions of workshops to explore feasible ideas of collaboration between HKIDP and manufacturers.

The researchers collected secondary and primary data and then analysed about 70 stakeholders, who represent the Hong Kong cases against the existing knowledge and six theories. They range

from four approaches of customisation[2] (Gilmore, 1997), OEM-ODM-OBM-OSM models of manufacturing[3] (Heskett, 2009), value chain, mass production and mass [scale] customisation[4] (Pine, 1993; Boston Consulting Group), and product-service system[5] (Morelli, 2006), to six spectrums of industrial innovation (Centre for Design Innovation, based on Stanford d.School). Moreover, the research team also reviewed literature that covers the existing publications, research papers, reports and studies by various industry professionals and the academia on scale customisation, Industry 4.0 and equivalent initiatives or movements, spanning from global to related knowledge of HKIDP.

All stakeholders who participated throughout the research phase are owners or senior management in their respective organisations. 24% of the researched candidates are 3rd generation leaders who inherited their HK family businesses established since the 1970s, 12% are design consulting businesses, and over 50% are manufacturers with over 20 years of industry experience.

The objectives of the semi-structured interviews are:

- to understand the respondents' perception, cognition, understanding and knowledge (OR all) of scale customisation;
- to explore if they are experiencing / using / trying to implement scale customisation;
- to investigate how to utilise the role of industrial design professionals / manufacturers / intermediaries (experts) in the process of scale customisation;
- to study how the industrial design professionals in Hong Kong select partner(s) of scale customisation / how the manufacturers would change mindset to prepare and equip for scale customisation; and
- to inspire the respondents to feedback on the environmental scanning factors of the needs and demands of Hong Kong consumers towards scale customisation

The research team synthesised the findings to recommend the best practice for HKIPD. The findings include (i) the methods for HKIDP to select manufacturers [suppliers] of scale customisation, (ii) the standards of the external market, and (iii) the ways to change mindset to prepare and equip for scale customisation. As conventional wisdom suggests, both challenges and opportunities are reserved only for those who are upgrading their mindsets and attitudes rather than technological infrastructure, for collaboration. A new paradigm in which all stakeholders across the industrial landscape work collectively and synergistically to increase multiple benefits is emerging.

The research is conducted in two core forms: primary research and secondary research, with 70 scale customisation specialists and industrialists, industrial design professionals, institutional leaders and global industrial experts.

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[2] Gilmore, James H., (1997). "The Four Faces of Mass Customisation." *Harvard Business Review, Jan-Feb*. Harvard Business Publishing. Retrieved 12 December 2018 from https://hbr.org/1997/01/the-four-faces-of-mass-customization

[3] Heskett, J. (2009). What is design?. Retrieved from https://www.edb.gov.hk/attachment/tc/curriculum-development/kla/arts-edu/references/va/seminar%20notes_by%20John%20Heskett_%20version%20before%20editing_rev.pdf

[4] Pine, B.J. (1993). "Mass Customization: The New Frontier in Business Competition." Boston, Mass., Harvard Business School Press.

[5] Morelli, N. (2006). *Developing new product service systems (PSS): methodologies and operational tools*. Retrieved from https://www.researchgate.net/publication/245167505_Developing_new_product_service_systems_PSS_methodologies_and_operational_tools

The primary research methods include exploratory research with focus groups, semi-structured interviews, participatory observations in workshop settings, interactive research board in public exhibition.
Secondary research is the information gathering from existing publications, research papers, reports and studies by various industry professionals and academia on scale customisation, Industry 4.0 and equivalent initiatives or movements, spanning from global to related knowledge of Hong Kong Industrial Professionals.

1.3 Research Strategy

1.3.1 Secondary Data Collection
- Industry 4.0 and equivalent initiative or movements
- related knowledge of HKIPD

1.3.2 Primary Data Collection
- Approximately 70 semi-structured interviews
- Three thematic workshops
- Interactive installation at the pavilion

1.3.3 70 Semi-structured Interviews
- Including experts of Industry 4.0, scale customisation specialists [and industrialists], in-house industrial designers and non-in-house industrial designers in Hong Kong
- Semi-structured questions, please refer to Appendix A for the list of interviewed questions.
- Face to face interviews
    - Industrial Designers
    - Industrialists
    - Domain Experts

1.3.4 Research Topics
- How can we enable HK industrial design professionals to meet the needs of scale customisation for future design and manufacturing?
- Define the scope and direction of focus
- What is the global progression and local understanding of industrial 4.0, mass production and scale customisation models and strategies?
- Identify the trends and impacts of mass production to scale customisation in the industry

1.3.5 Three Thematic Workshops
- 3 thematic topics: IoT, Big Data and Product Service model as thematic discussion for innovation breakthrough
- Design tools: personas, problem framing, technology trend shifts, concept link, challenge questions, stakeholder map
- Ethnographic observation and action research on participant knowledge to content engagement

1.3.6 Interactive Installation at the Exhibition
- Inspired by “WHAT MADE ME” installation, by Dorota Grabkowska, Birmingham, UK
- 66 elements related to design and manufacturing

- 400 visitors participated to contribute answers to the 4 questions: “what you value”, “what you do”, “what you want”, and “what you change”

1.3.7 Data Analysis

Comparative Analysis

- Affinity clustering - differences and similarities
- Insight finding: discover patterns and characteristics
- Evidence finding

Conclusion

- Insights on challenges, recommendations and opportunities

2. Literature Review

2.1 What is Industrial Design?

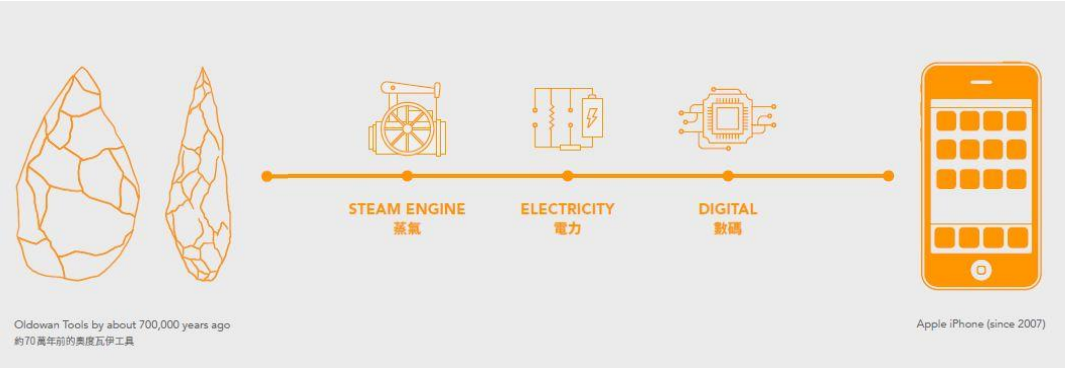
Industrial Design (ID) is a discipline that has been taught and practised for centuries. In business dictionary, industrial design is defined as the process of designing the shape, features, etc. of manufactured products. And in the famous book written by John Heskett in 1980, “Industrial Design” provided a holistic view of the industrial landscape in response to changes in production methods and economic changes during the time[6]. Quoted from Heskett (2005), “[Industrial] Design is when [industrial] designers [industrially] design a[n] [industrial] design to produce a[n] [industrial] design.”[7]

The definition of industrial design originates from mechanical production processes, and design as connotation of art and industrial of mass production needs to be redefined to include digital production paradigm. Industrial design is a practical result of prolonged study and shaping of people’s behaviours for the formulation of tangible (product) and intangible (service) aids to optimise and nourish the operation physically and psychologically. Referencing from Prof Eric C. Yim (Chairman, Design Council of Hong Kong; Deputy Chairman, Federation of Hong Kong Industries), “industrial design covers all artefacts in daily life,” and with economic considerations for mass production. From micro level activities to macro level thinking with design management and strategies, ID involves user-centric design, manufacturing capacities, technological applications, business strategies and organisational development. There are multiple streams in which industrial designers specialise and branch off, and most commonly known to the public are product designers.

2.2 Industrial Design Then and Now

ID has moved from a simple stone cutting tool several millennia since, to handcraft products based on manual proficiency and then the pre-industrial era, which commenced the division of labour and the collection of repeatable patterns and processes during the Renaissance in order to speed up the production efficiency for trading purpose. With the introduction of assembly line and mechanisation, products and parts could be manufactured identically by machines. The production efficiency achieved through mass production led to the mass consumption phenomena.

Figure 1
A timeline of major industrial and design milestones



[6] Heskett, J. (1980). *Industrial Design*. Thames and Hudson. Retrieved from https://books.google.com.hk/books?id=uUOIQgAACAAJ

[7] Heskett, J. (2005). *Design: A Very Short Introduction.* USA: Oxford University Press. p. 3. ISBN 978-01-916-0661-8.

The society is living in the digital information era now, and this is due to the advancement of technology. Physical functions of products are now augmented into digital space, leading to higher interactions and inclusive user experience. Digitalisation has liberated traditional industrial design from physical boundaries to virtually endless possibilities. This requires a change of philosophy in terms of what society defines products, artefacts and designs should be. The methodology behind the construction of design and innovation, which leads to game-changing products is a complex process of design thinking, from understanding users and market, realisation to ideation, materialisation to sustainment. Most important of all, **the method of design thinking requires high collaboration between cross-disciplinary individuals**, as this fosters collective insights and equip non-design-oriented business with new creative opportunities and growth. Industrial design incorporates the essence of design thinking, and the application of this methodology has propelled many organisations to be the new innovative leaders globally. Therefore, industrial designers are the key drivers in manufacturing to provide holistic solutions, where business viability, design usability and technical feasibilities meet together.

2.3 How Industrial Designers Approach Design?

2.3.1 Mindsets for Industrial Design Professionals

The essence of value creation to consumers has changed, and most important of all, the understanding of information derived from new manufacturing systems and consumer expectations are key to success. Industrial design professionals need to have combined knowledge on business viability, user desirability and technological feasibility. According to the design thinking Venn diagram model created by Stanford University D.School, it indicated the “sweet spot” in which all three dimensions intersects, resulting in design innovations.

User Desirability

In order to fulfill true user needs, design should start with people. Most of the time, designers associate moments of a-ha (spurs of sudden creativity) from their surroundings and experience. When speaking to some Hong Kong product designers, the question “How do you get your inspirations?” was asked. Their common answers fall to trends and insights from their living environment. However, the understanding of human values lies beyond users’ interaction with the artefacts, it also includes the understanding of the root of desires - the reasons in which users’ needs exist and the relationship of the artefacts to the users themselves.

Too often, designers avoid engaging users directly and fall into their own design presumptions - a creative complex in which designers live in their own bubble of thoughts. Borrowing a famous quote from Tim Brown from IDEO, a global design consulting firm, he noted, “Instead of thinking about building we have to build to think.” It is undeniable that designers are passionate with crafting and tinkering, and it is especially easy to jump straight into design without full awareness of all conditions. There can be many insights drawn through ethnographic and participatory studies on consumers’ behaviours, resulting in higher empathetic understanding of real users’ needs.

Business Viability

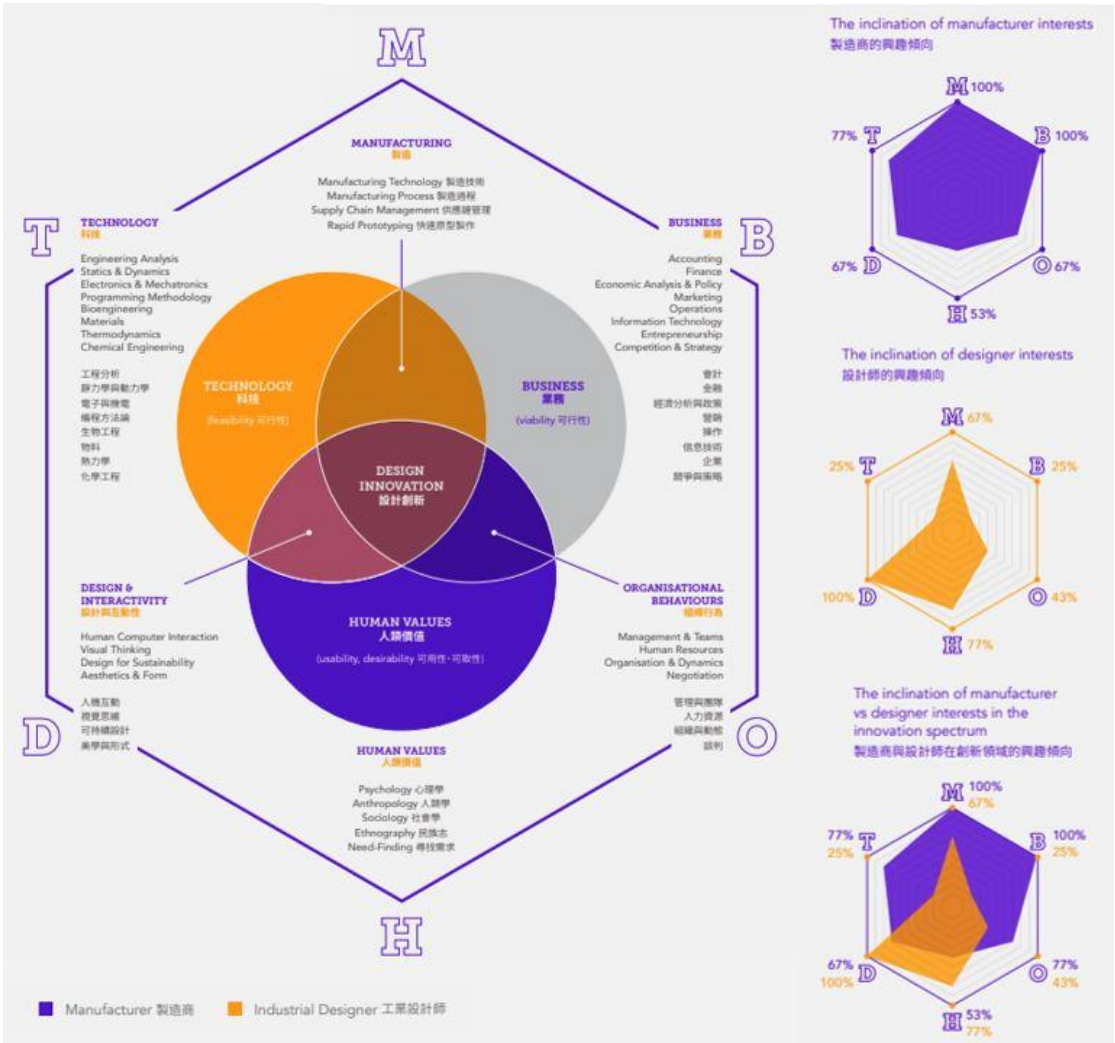
Everyday businesses are confronted with decisions, whether they are challenges or opportunities. In the manufacturing sector, the speed to commercialisation, or speed to market, is particularly crucial for product survivability. How can industrial designers assist manufacturers in deciding the

right products to manufacture? The highest economic return? Any consumer products, even non-perishable artefacts, are not timeless and have limited life span. The success of product design in manufacturer metrics is the return of investment. The longer the products sit in stores and on shelves, the lesser the monetary value perceived by consumers. The most desirable solution is that industrial designers have clear vision and metrics, which align to the manufacturers' business value propositions - a broadened vision with long-term winning design and cost-effective strategy.

Technology Feasibility

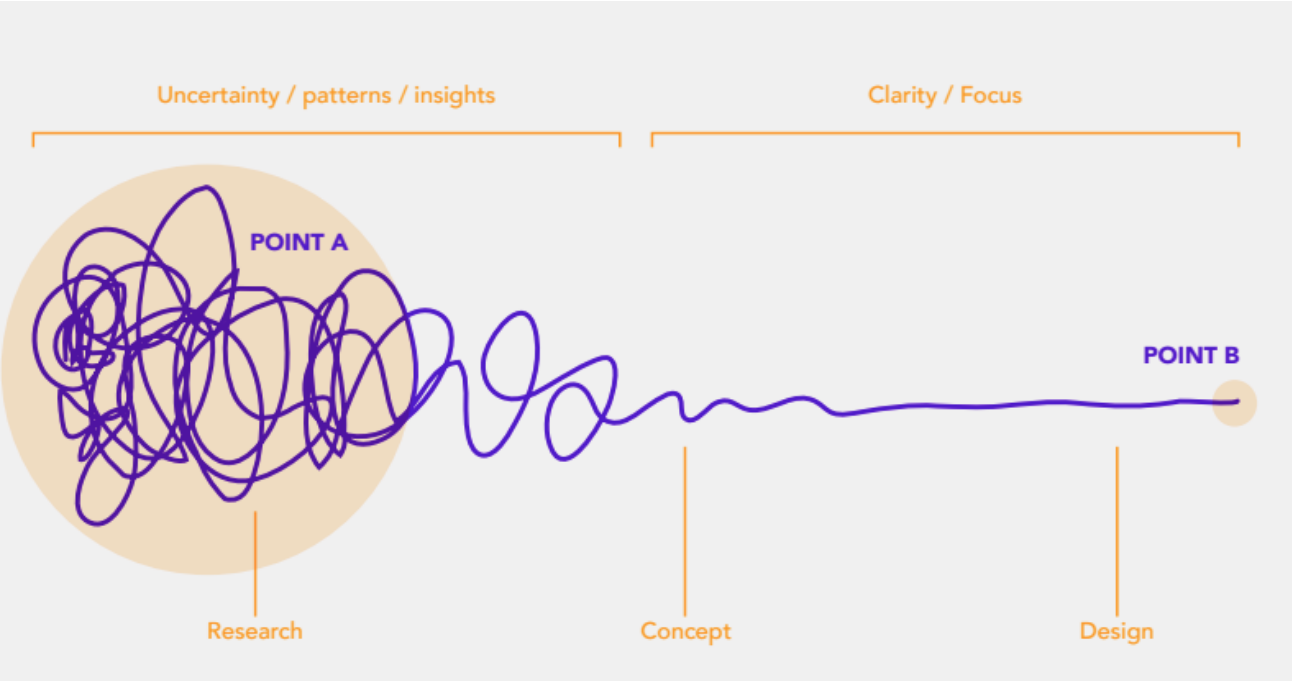
In the Fourth Industrial Revolution, technology plays a huge factor in the design and manufacturing processes. The technical capabilities in production must be on par with the rapid market changes. No matter how innovative and groundbreaking a new product or service offering may be, the feasibility of implementation can hinder the creative efforts. Successful industrial designers leverage small task forces, teams comprised of designers, engineers and marketing and sales, to collaboratively conduct sprints of conceptual designs and prototypes, and maximise data to perform feasibility studies. With real-time data on manufacturing processes and on consumers' usages, advanced technological systems enable designers to make faster and better decisions.

Figure 2
The design thinking Venn diagram model, created by the Stanford University D.School, indicated the "sweet spot" in which all three dimensions of business, human values and technology overlap, resulting in design innovations.



The value of striving harmony among the three dimensions yield great results: Consumers' lives will benefit from greater products, resources will be better allocated and used effectively, executions and operations will be more optimised. However, according to "the Squiggle" by Damien Newman, the process of design is unorthodox, and not meant to be straight from point A to point B[8].

Figure 3
"The Squiggle" by Damien Newman reflects the process of design is unorthodox, and not meant to be straight from point A to point B.



Observing from the research dialogues conducted with local established designers and industrialists, the individuals all share the notion of "T-shaped" thinking to assist them in navigating through the world of complexity. According to Tim Brown, CEO of IDEO design consultancy, the horizontal stroke of the "T" signifies for collaboration across disciplines, increasing both depth and breadth in skills. Whereas the vertical stroke of the "T" represents the split between human left and right brains[9].

Innovative designs sprout from ambiguity, and the process of navigation until clarity is identified required intensive and extensive exploration to unravel patterns and insights. This experimentation process cannot be fruitful if conducted alone, it must be a collective journey in which individuals from multidisciplinary background, be it industrial designer, manufacturer, engineer, architect, business specialist, to cocreate the knowledge together.

[8] Newman, Damien (2002). "The Design Squiggle." Retrieved from https://thedesignsquiggle.com/
[9] Hansen, Morten T. (2010). "IDEO CEO Tim Brown: T-Shaped Stars: The Backbone of IDEO's Collaborative Culture." Retrieved from https://chiefexecutive.net/ideo-ceo-tim-brown-t-shaped-stars-the-backbone-of-ideoaes-collaborative-culture trashed/

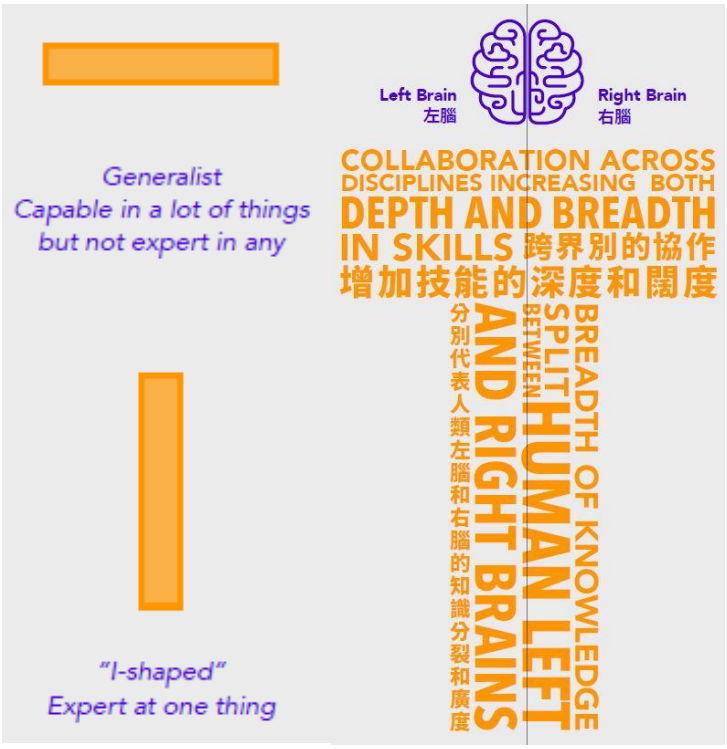
Good ideas are constructively built and nurtured upon one on top of another. Thus, in order to effectively make sense of the unfamiliar in the early chaotic research to conceptual phase, “T-shaped” settings become valuable. Teams and individuals with this way of thinking synergise creative and practical thinking together, and develop systemic methods to approach innovative designs. The widened array of thinking allows information to be integrated, seen and communicated in multiple perspectives in which singular mindsets cannot attained.

The hard truth about innovation: It’s one part creativity, one part discipline.

The Hong Kong industrial realm has a vast untapped area of information, from people to machines, that can be fruitful to propel the next manufacturing evolution. Preceded with lack of information, designers and manufacturers will be navigating and making decisions with uncertainties given that there is absence of knowledge. The outcomes in turn result in potential organisational losses and ineffective solutions.

The world is now connected as a mesh network, whether it is human to human, human to machine, and systems to systems. Traditional education and work settings facilitate “I-shaped” (individual depth-skill without communication skills) behaviors, particularly in manufacturing where people are specialised in each assigned workstations and working in separation from other disciplines. This old model will hinder innovation and progression, especially when manufacturing environment is rapidly transforming through technologies. Therefore, industrial design professionals need to realise their skills and minds need to be cultivated in alignment to the industrial revolution ahead in this changing economy.

Figure 4
The T-shaped skilss in which the vertical “I” bar of the T referes to expert knowledge and experience in a particular area, while the horizontal top of th T refers to an ability to collaborate with experts in other disciplines and a willingness to use the knowledge gained from this collaboration.



3. What is Mass Customisation?

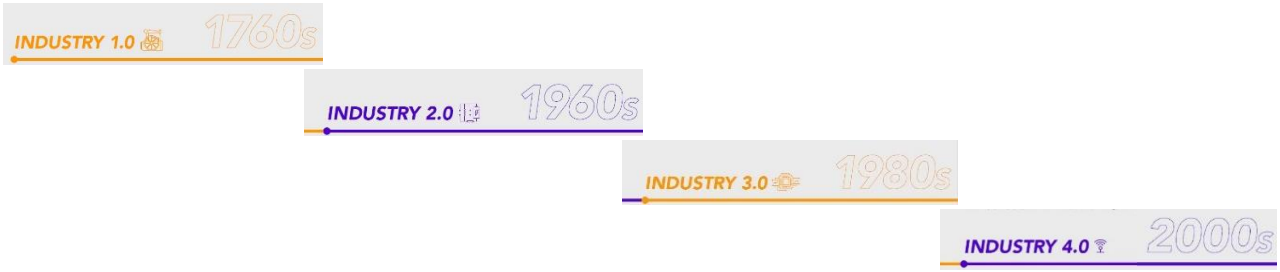
AT A GLANCE

THE ADVANCES
Advanced 4.0 technologies (9 pillars) have liberate designers and manufacturers to become more flexible in production and responsive to real-time consumer needs. The progression enhances innovation capacities with consumer-centric approach, resulting in more accurate and inclusive designs.

THE AREAS OF TRANSFORMATION
Manufacturing landscape is radically changing in design, production and retail value chain. From technological infrastructure changes to business strategic modelling, the ways in which scale customisation in Industry 4.0 applies require new skills, mindset and learning attitude.

3.1 Comparison of Global Progression in Industrialisation to Hong Kong

Figure 5
The Global Economic Progression of the Fourth Industrial Revolution



Industry 4.0 is a terminology widely used to define the fourth industrial transformation in the manufacturing and industrial design sectors. There may be other notations referring to the same transformation across the world, but putting that aside, manufacturers and designers must recognise this revolution as a significant change. It will not only affect the methods and systems in manufacturing production, but also changes the way products are designed and its ways to interact with consumers. First, to understand the implications of fourth industrial revolution, one should reflect on the historic progression in manufacturing.

The first industrial revolution took place over three centuries ago, started in the 1760s. It is one crucial milestone in the humankind evolution, as many sources of energy were still in discovery. During this era, horses were still a great source of energy to extract water out of mines and woven clothes in textile production were costs ineffective. There was a necessity for innovation to break the paradigm to increase operating efficiencies, and throughout this period, scientists invented the steam engine. The innovation proved that the revolution of this new source of energy changed the production process drastically. From the introduction of railways to steamboats, the steam powered mechanisms were also incorporated into textiles, printing press and more.

Certainly, the first revolution seems to only revolve around steam power on machine inventions, but one thing to note is the production of iron as a material. In the 1700s iron production relied on furnace heating, powered by coals, and heavy labouring was required to cure the metals. However, steam powered furnace transformed the method of iron production, yielding in better production control and higher quality finished products. Another thing to note is the transfer of knowledge and training for manufacturing workers. With the appearance of printing press, publications, records, and documentations were more convenient to share among higher societies, such as industrialists, scientists, philosophers, inventors and more, and travellers from abroad. The mediums allowed knowledge to be communicated and trained through apprenticeship to labourers.

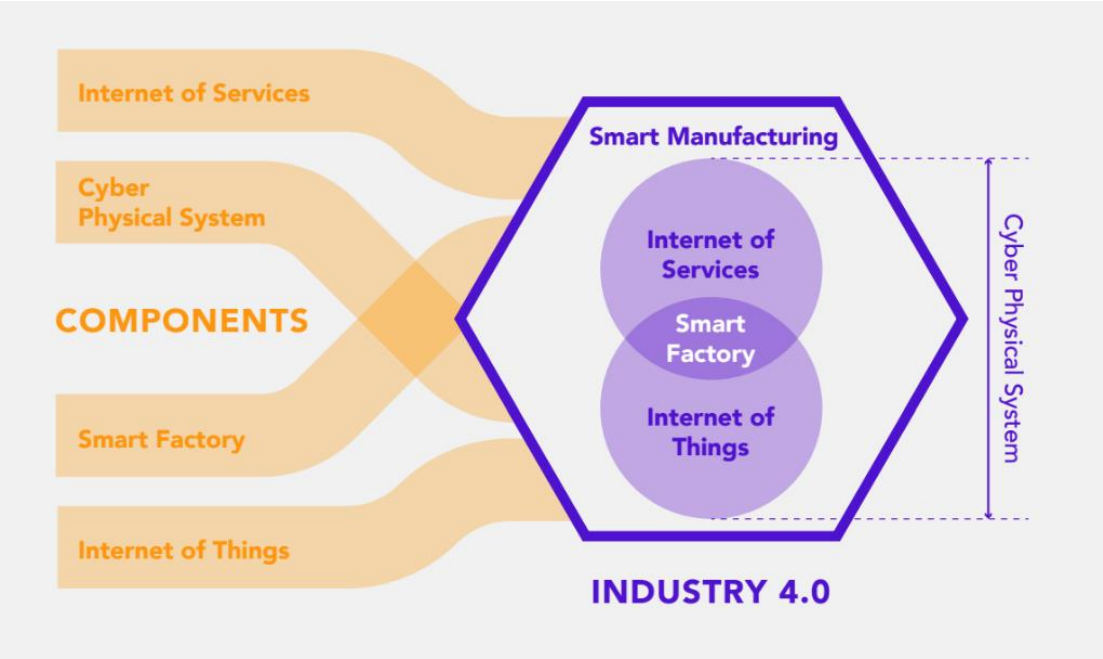
In the late 1800s, just a century apart, the industrial world had another shift. The introduction of electricity, oil and gas enabled another innovation breakthrough in manufacturing, transportations and communications. Although there were remarkable inventions such as the light bulb and aircrafts, but the ultimate revolution that redefines manufacturing sector was the introduction of automotive assembly line by Ford. In an **assembly line**, manufacturing workforces are distributed and assigned with specific activities across the production chain - commonly known as division of labour. The separation of duties reduces one labourer to understand and conduct all activities from end to end, mitigating the risk of failure and can further optimise the outputs from labourers while each of them specialise on specific tasks, repetitively. Through a chain of assembly, each labourer will pass on the completed parts from one workstation to another, added in sequence, until the final product is assembled.

Through leveraging mechanised machineries and tools, such as conveyor belts, each part can be built and transferred without labourers carrying, which significantly increases the speed of production and lower the costs - initiating the era of mass production. Made-to-stock production cycles enable products to be offered to mass consumers at low and affordable costs, while customised products, also referred to make-to-order production process, has been treated at higher price points due to longer production lead times and complexities of design and functions. As mass production reached its peak, economies of scale allowed manufacturers to produce affordable products for consumers without jeopardising profit margins. The success of mass production can therefore be summarised as interchangeability, the ability to assemble by parts, moving assembly line and division of labour.

By the 1980s to 1990s, **computerisation and internet democratised knowledge and information**, resulting in a huge leap forward on humankind. The boundaries of innovation again expanded with advanced robotics, nanotechnologies, renewable energy and more. Manufacturing productions become further streamlined and automated with better machineries, and internet facilitated and catalysed the exchange of data transmissions.

Moving into the modern era, the fourth industrial revolution is taking shape. As Industry 4.0 unfolds, computerised machines and systems can further integrate and communicate via cloud computing, relaying information at real-time speed with minimal human assistance. **The combination of cyber physical systems and cloud platforms** allow manufacturing to become more intelligent, also widely known as smart factories. The heightened transparencies and accessibilities of data made production far more efficient and productive than ever in history. Digitalisation and connectivity facilitated hyper communications via machines remotely, decentralisation production chain and unbounded physical restraints.

Figure 6
The cyber physical system (CPS)



3.2 Hong Kong Economic Progression in Industrialisation

The race to Industry 4.0 is a global trend in manufacturing sector. The USA and Europe had been leading in the progression in early 2010s, with China dramatically undergoing the transformation. However, Hong Kong, which was once in the global leadership role in manufacturing, now lag behind on the world stage.

Figure 7
The period of time for Industry 4.0 and equivalent initiative or movements

When Hong Kong transformed from an entrepôt to an industrial city in the 1950s to 1960s, the foundation and economic structure of the manufacturing landscape was created. Many Hong Kong designers began to emerge, practising modern design with Western design theories and principles. It was also then when Hong Kong design schools and institutions had first been borned. As time shifted into 1970s, the reduced tariffs on import and export further accelerated the growth of industrial sector, particularly in manufacturing of toys, electronics, watches and jewelleries, levelling the playing field with clothing and textile industries. The financial success of many manufacturing industries has benefitted from the economies of scale through mass production, and this was made possible with the maturation of Industry 2.0 mechanised machineries and also the cheap human labours at the time.

During the 1980s, China underwent a political reform and announced the open door policy. At the same time, the rising costs of labour and real estate in Hong Kong drove many manufacturing businesses to relocate their production operation in China. Towards late 80s and early 90s, many industrialists have relocated factories beyond China to other Asia Pacific countries, such as Thailand, India, Myanmar, Bangladesh, Vietnam, Indonesia, Malaysia, and the Philippines. As an open city, Hong Kong continued to capitalise on the economic reform in China and advancement in financial, real estate and manufacturing industry. Hong Kong industrial sector began to scale up to deliver value-added activities in product and service development, while upgrading technologies to minimise production costs and maximise labour-intensive activities through cheaper labours in less developed regions outside of Hong Kong.

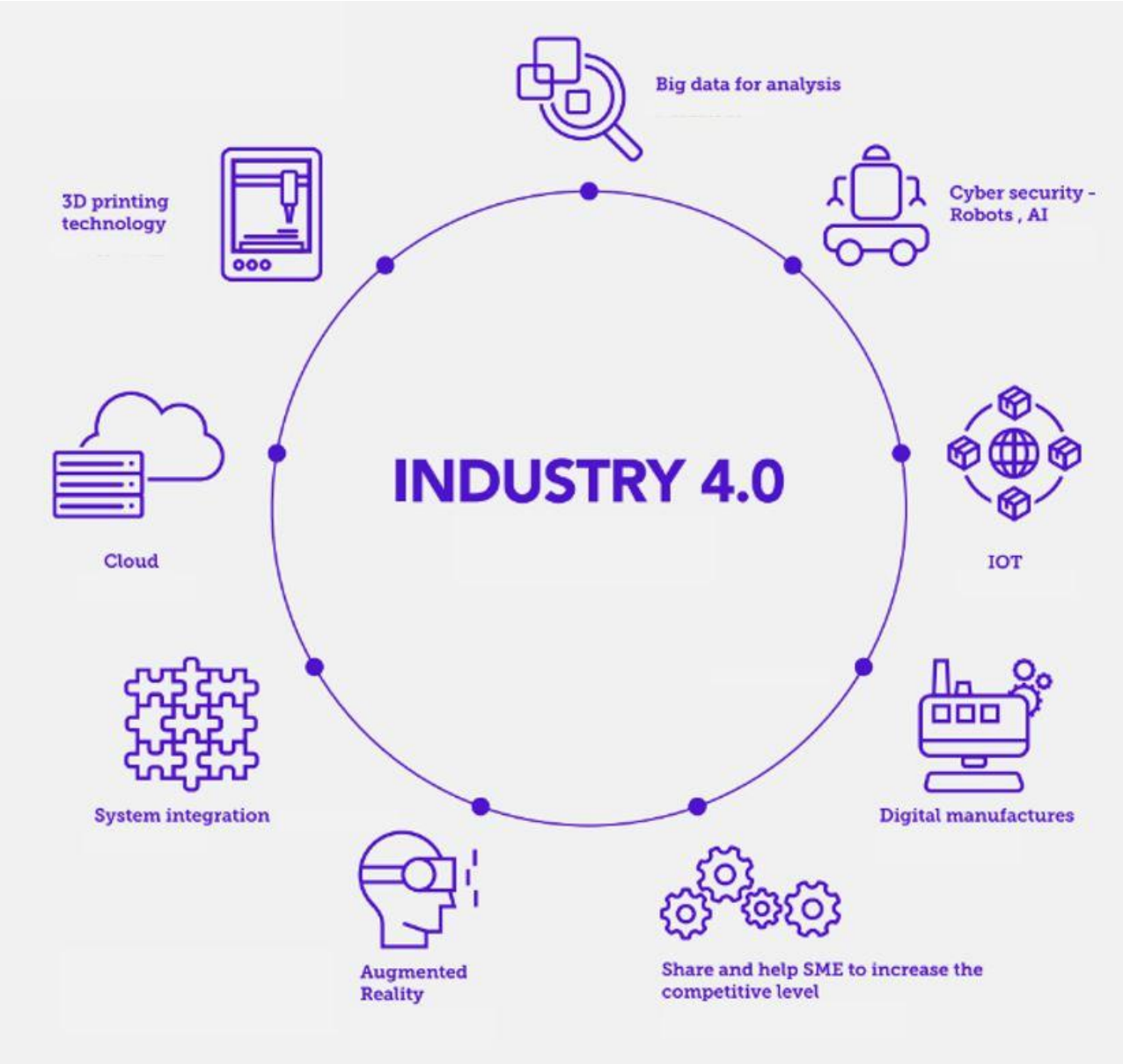
This left service-based activities in manufacturing, such as investment, design and management processes, to remain in Hong Kong. The change in the economy brought forth the tertiary industry, particularly services to support the manufacturing industries abroad. With manufacturing-related activities migrated remotely with the factories, many Hong Kong industrial businesses had disassembled and scaled down the organisation structure, leaving small to medium service units, from as small as 3 employees to 100, in Hong Kong to locally conduct the administrative, legal, trading, design and strategic management tasks.

Referencing from several industrial experts and academics in Hong Kong, many Hong Kong manufacturers and designers are still in midst of automating their factories and gaining knowledge from Industry 2.0 to 3.0. This could be due to lack of exposures to information and training opportunities, insufficient governance and support, as well as lack of supportive funding. As noted by the founder of Genic Eyewear, without a technology implementation partner and government subsidies, the transformation in leveraging selected Industry 4.0 technologies would never had happened. Meanwhile, many Hong Kong manufacturers have yet to tap into these available resources.

3.3 What is Industry 4.0?

According to Boston Consulting Group, a globally recognised management consulting firm, Industry 4.0 is formed by nine technological pillars, which some are already being used in parts of production. However, it is when all are fully integrated and automated, then production flow gets truly optimised with 4.0 technologies.

Figure 8
The nine technological pillars of Industry 4.0



Autonomous Robots

Industrial robots have long existed in the manufacturing environment to assist in difficult tasks, ranging from heavy lifting to dangerous and complicated duties. These traditional robots are commonly huge in size, single task, and cannot be used in activities with high dexterity and precisions with small parts. However, advanced robotics in modern era have become more autonomous and flexible. Industrial robots are now capable to cooperate safely side by side with humans, while communicating between machines through integrated sensors and interfaces. With greater range of capabilities, the modern robots can be applied in bigger ranges of duties in manufacturing environment now. According to research with some Hong Kong manufacturers, advanced robots have been implemented, increasing their overall production by at least 30% and reducing front line labours by over 60%. Some have even indicated that the overall organisation size in production has reduced to one tenth of the original with throughput increased threefold.

Simulation

Simulations of objects in product and material designs have long been in practice since. The differentiation in Industry 4.0 is due to the extensitivity of usage in manufacturing environment. With integrated sensors, real-time data can be captured and analyse simultaneously in conjunction with the physical space, resulting in a mirror of the physical environment in the virtual world. The virtual simulation will be able to map out all machines and objects across the value chain, allowing manufacturers and designers to experiment and optimise designs and settings for respective line of products prior to real world production. This mitigates potential risks of failure and setup times in live production. Another term commonly known in this simulated environment is called digital twin.

System Integration

Achieving full system integration across functional units within an organisation has been a pipedream for many. Horizontally and vertically, design, engineering, production, logistics and retail systems generally operate separately from one to another, leaving the information between units reliant on verbal conversations and tons of file transferring and documentation. By leveraging Industry 4.0 technologies, cloud platforms and centralised data systems allow data communication to be further standardised across multi-stakeholders, thus unify the network of systems to deliver better transparencies and communications.

Internet of Things

Although commonly known as smart devices and gadgets in consumer markets, many manufacturing systems have yet to fully leverage the power of connectivity to production systems and machines. Traditionally, through embedded chips and computing systems, each machine controller can monitor and provide system data for analysis, but the data extraction was one-directional. With industrial IoT embedded as new computing technologies to machines, the devices can now transfer information and communicate simultaneously with one another via the cloud as centralised control system, creating multi-directional communication between networked objects. Each step in the production cycle can be now captured and identified, shared among all machines, to become more adaptive and agile during the manufacturing process.

Cybersecurity

With the increased usage of technologies and virtual communications, the risk of data loss and security to cyber threats become bigger needs in the manufacturing environment. Open systems will require a higher level of access management controls and secure sources of data transmission. Information technology management practices therefore become crucial.

Cloud Computing

The existence of cloud-based platforms and systems have demonstrated increasing values in manufacturing. Data sharing across on and off-site locations removed the boundaries of communication, achieving more real-time data control and monitoring for production systems. Open systems will continue to generate huge data volumes in which cloud technologies will be leveraged.

Additive Manufacturing

Additive manufacturing, particularly 3D printing, has been introduced to the market in the 1990s. While the cost of usage was high in the past, many manufacturers and designers have now integrated 3D printing for rapid prototyping and spare parts production. The technology is mostly suitable for small batch-size production for highly customised products in complex and lightweight designs. However, traditional moulding used for manufacturing productions is also shifting to be 3D

printed with advanced systems. Sophisticated parts in aerospace and aircraft designs are leveraging additive manufacturing systems to lower production expenses in raw materials usage and assembly.

Augmented Reality

Augmented reality, also abbreviated as AR, is a virtual augmented environment in reality. While not commonly seen or used in manufacturing sector now, the technology has been commonly applied in gaming and even housing. AR systems enable workers to engage in real environment via virtualism. This is particularly useful for maintenance and standard operating procedures.

Big Data

Across research in Hong Kong manufacturing landscape, data capturing and analytics are still at its infancy. The collection and evaluation of data can come from many different forms and sources, from production systems, enterprise level software to customer relationship management platforms. Without upgraded platforms like Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Manufacturing Execution System (MES), Customer Relationship Management (CRM) and integrated machine data, manufacturers and designers will not have full transparencies to make better and quicker decisions to support emergencies and to scale up production values.

AT A GLANCE

THE GLOBAL MARKET SHIFT
Consumer market is becoming more and more fragmented from mass consumption - resulting in niche segments. Consumers are empowered through technologies and medias with higher accessibilities to products and services and transparencies of information.

THE PROBLEM
Many Hong Kong industrial professionals still hone onto mass production, and misinterpret customisation needs as personalisation of products. This set back design and manufacturing strategy to meet the changing consumer needs in today's economy.

THE OPPORTUNITIES
Understanding scale customisation as industrial strategic approach with the adoption of technologies, particularly advancements from Industry 4.0, will accelerate internal and external production capacities to better serve the growing niche markets.

3.4 Hidden Figures

In the era of fast changing consumer market, the rise of the niche marked the start of a seismic shift where products are pulled based on actual market demands rather than pushed based on reports and forecasting. Consumers no longer play passive roles in the production value chain, and their behaviours will continue to influence and disrupt the ways in which design and manufacturing should approach the market.

Mass production driven by OEM business model will put manufacturers and designers in the bottom of the production value chain. It is now critical to understand and meet the pace of our consumer needs, such that we can reposition the new value of scale production and design with Industry 4.0 technologies.

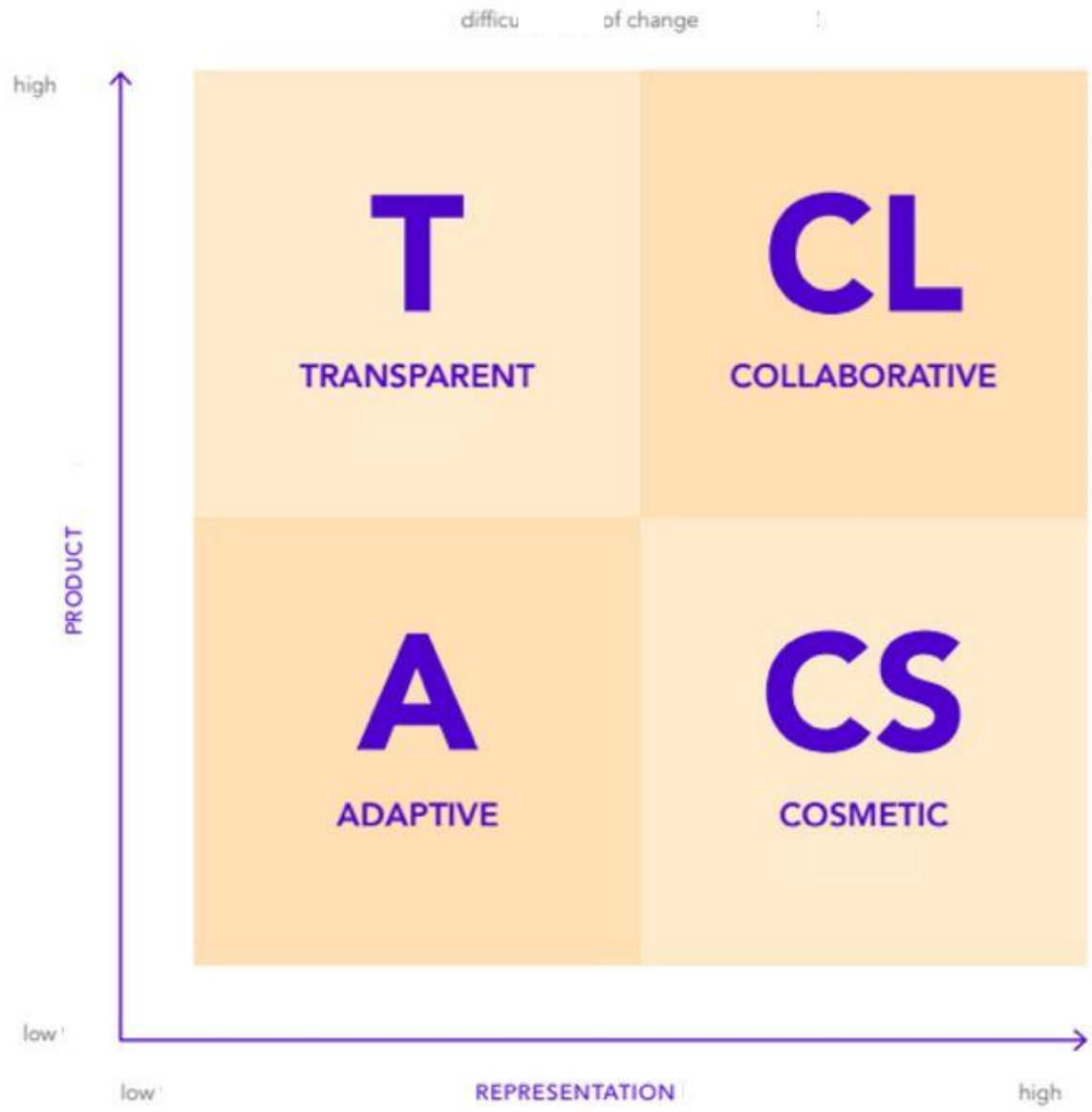
The seismic shift from mass market to niche market, or generalisation to customisation, is happening. The niche increases the viability and specifics of what you can cater to your audience. Consumer markets will continue to be diluted with varieties and choices, and the niche will become the new mass market.

Research has reflected less than 10% of Hong Kong consumers demand highly customised products. The rest of the 90% still consume and make purchases based on what is offered in the existing market. This does not mean that customisation only took place within the 10% spectrum. Deeper analysis has allowed the research team to discover that “highly customised products” refer to personalised goods, and these are different from products manufactured with scale customisation strategy. In order to achieve clarity in consumer customisation needs, it is important to first decipher and break down the information.

Figure 9
The ratio of demand for customized products

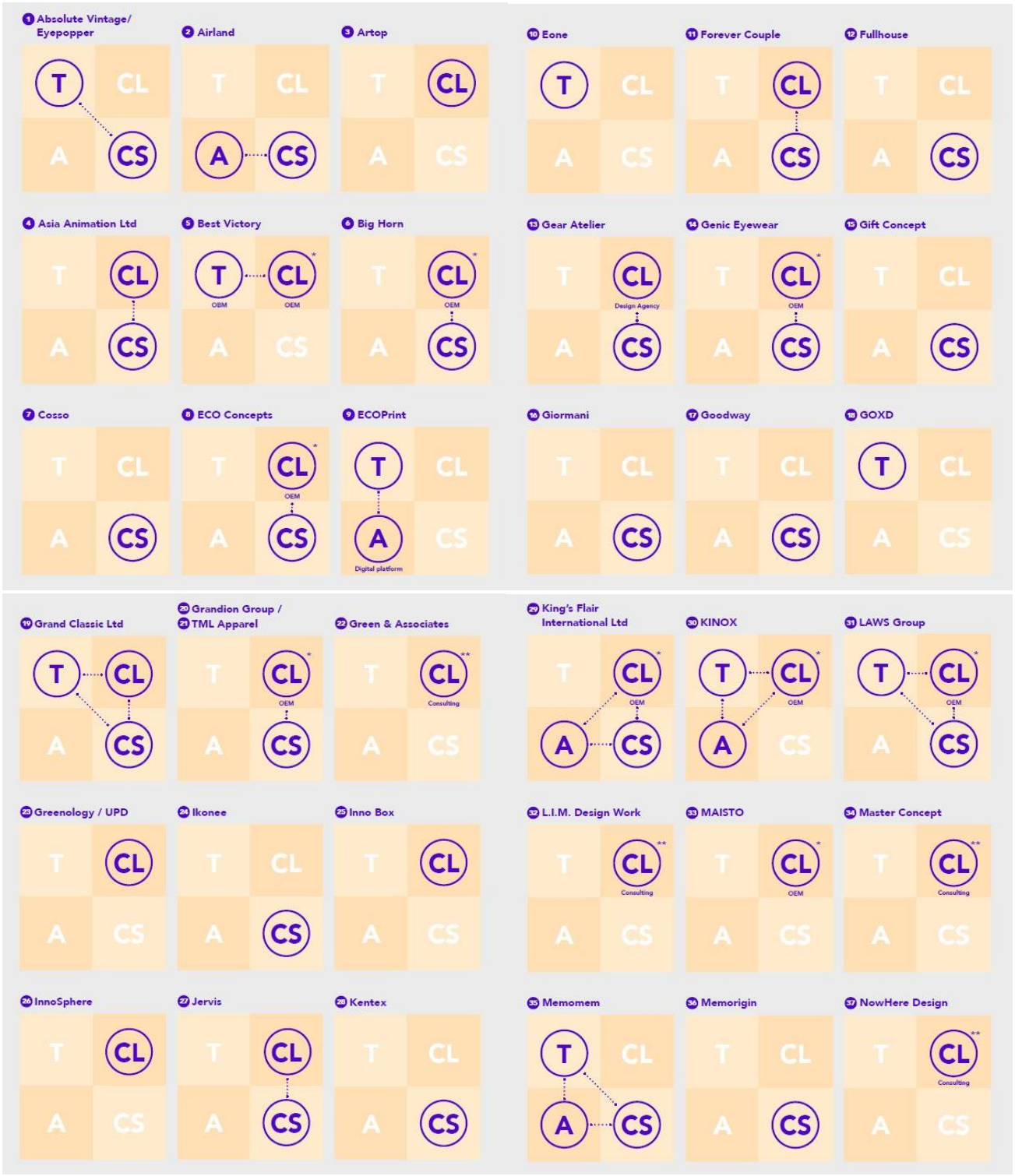
In 1997, Harvard Business Review published an article, elaborating on four kinds of customisation needs in consumer lens. First and foremost, the types of consumers identified are not mutually exclusive from one another. There are consumer types that may overlap; therefore, designers and manufacturers will require to have more holistic understanding on the niche markets in which they serve. Therefore, it is important to understand customisation needs from consumer lens (what the niche is) to align with design and manufacturing capacities.

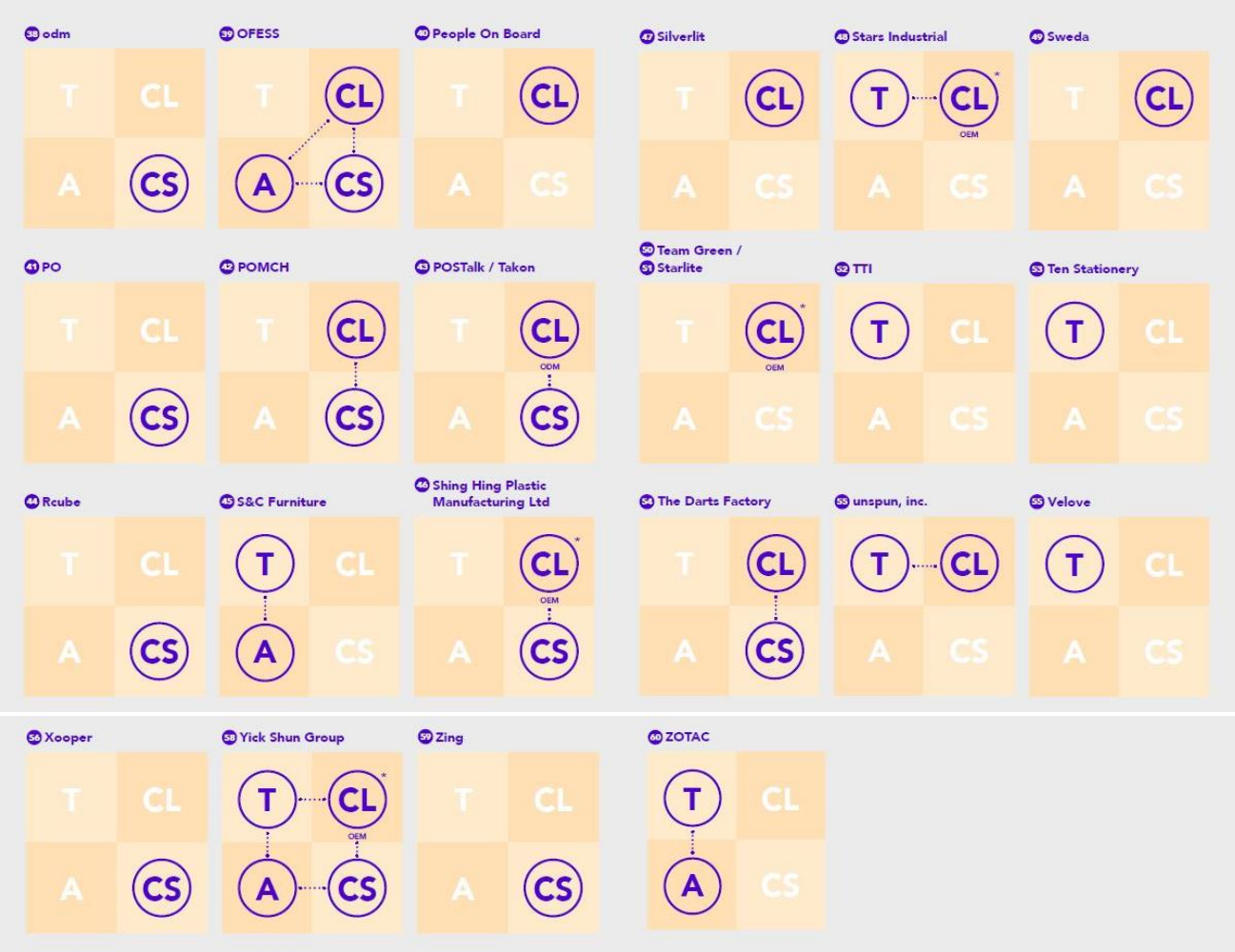
Figure 10
Four Approaches of Customisation[10]



[10] Gilmore, James H., (1997). "The Four Faces of Mass Customisation." *Harvard Business Review, Jan-Feb*. Harvard Business Publishing. Retrieved 12 December 2018 from https://hbr.org/1997/01/the-four-faces-of-mass-customization

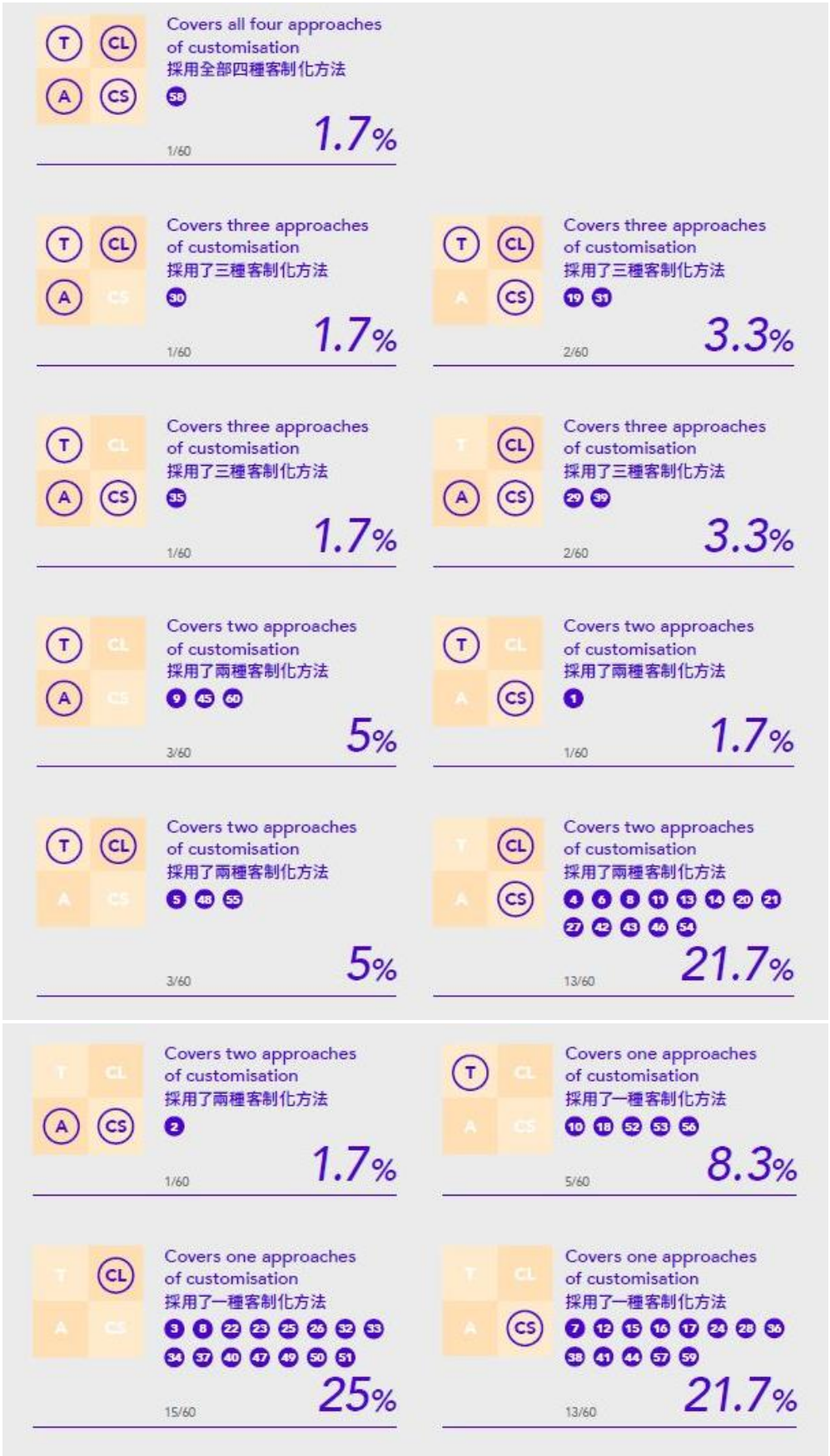
Figure 11
The interviewed companies as case for Four Approaches of Customisation categorization





Due to the different levels and scales of operation and business nature, the four approaches of customisation model here do not reflect 100% of the state of all interviewed companies. The comparison has been generated with the exceptions of 9H, ACE, ChinaDesign Research Work-Group, ENICMA, Fraunhofer IPT, Hong Kong Productivity Council, Mings 3D / Hong Kong 3D Printing Association, OMG, the Vocational Training Council and Wonderlaine Studio to maintain a fair and compatible representation.

Figure 12
Overall statistic of Customisation Approach(es) of interviewed companies



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Collaborative Model

In a fully collaborative model (very high change in product and representation), designers and manufacturers are required to fully articulate consumers' needs and provide bespoke products. Consumers are engaged early in the design cycle, working hand-in-hand with designers and manufacturers to specific solutions. Traditionally, designers have to go through lengthy, and often iterative, cycles of conversations to gather the requirements and scope prior to conceptual ideation of product design, leading to longer production time frames and complex manufacturing steps. However, with the advancement in technologies, more tools and systems are available to assist designers in understanding consumers' desires in real time.

For example, Forever Couple Limited, a couple ring manufacturer in Hong Kong, utilise a 3D scanning machine to dissect exact finger sizes of each ndividual. Along with custom styling, the results are more precise quantifications and higher degree of fitting than standard measuring tools.

About Forever Couple Limited

The Forever Couple collections are created to customise every wedding ring by scanning the exact finger size with 3D technology, the "Sizing Master". With detailed data analysis, a 3D prototype ring is produced for every customer to wear on the go, with the perfect ring to be carved through standardised production process.

Adaptive Customisation

Whereas in adaptive customisation (low change in product and representation), products are standardised with customisability. In most circumstances, consumers prefer to satisfy multi-purpose occasions with lesser products. Similar to a handyman who would like to have an all-in-one tool than carrying stacks of tools, not only is it troublesome to carry but also inconvenient. According to Fraunhofer IPT, a smart table with customisable digital interface to home lighting and temperature controls is produced to meet this market demand.

About Fraunhover IPT

The Fraunhofer Institute for Production Technology IPT, aka Fraunhofer IPT, is an institution of the Fraunhofer-Gesellschaft for the Promotion of Applied Research eV. Its activities focus on applied research and development in the Subjects to Engineering and Mechanical Engineering. It partnered with Hong Kong Productivity Council (HKPC) and Vocational Training Council (VTC) for the launch of the first Professional Diploma Programme in Industry 4.0 in Hong Kong in 2018.

Transparent Customisation

Transparent customisation is often hard to be grasped. Generally, consumers are not fully aware of their own needs and wants. Designers need to deduce consumers' needs, often implicitly. This requires thorough observation on consumers' natural behaviours.

Gear Atelier Limited, a leisure product design agency, spotted an opportunity to redesign neck pillows. Travellers often sleep during flights. While many standard neck pillows are too soft in materials or too shallow in sizes, travellers have to bear with the discomforts due to the designs. Furthermore, the sleeping postures vary with individuals. In order to meet with the unspoken challenge, Gear Atelier design team experimented with multiple prototypes, finalising their design with sturdier materials like memory-foam pillows, added heights for better neck support, and a mechanism that can close off the open end to provide a 360° sleeping angle.

About Gear Atelier Limited

Gear Atelier is a renowned local design firm specializing in Original Brand Manufacturing (OBM) for the development of creative gift and household items, which are sold locally in Hong Kong and in more than 50 countries worldwide. Since its establishment, Gear has developed the brands of Living Gear and TAPAS for different market segments. Apart from its self-developed product series, Gear also provides design consultancy service to other companies in the area of branding and product design.

Cosmetic Customisation

Cosmetic customisation is by far the easiest approach of all and has the lowest degree of difficulty in production. This requires almost zero functional changes to the product design, only focusing on customising the presentation. As simple as engraving names on the product, applying customised designs on standard products, and even new packaging can be categorised as cosmetic changes.

One example can be referenced to Snaptee Limited, through its social integrated platform, consumers can share and upload any personal photos and images on-demand, personalise the t-shirt design for easy printing and shipping.

About Snaptee Limited

Snaptee Limited is a mobile app created to make designing and ordering custom T-shirts as easy as applying a filter to a smartphone photo. Snaptee's interface features Instagram integration, a wide choice of fonts and colours, custom filters and design templates. Finished designs can be printed onto 100% organic cotton T-shirts for and shipped anywhere in the world.

3.5 Niche is the New Black?

We all talk about knowing our consumers better, but what data are we really getting?

Traditionally, the success of mass manufacturing as a business model is to maximise shareholders' return through the pursuit of productivity. The model neglects input from consumers and end users, thus limiting innovation opportunities. When product turnaround times in the market increase, manufacturers are forced to raise inventory costs. However, businesses that generate higher values for consumers have significantly scale and outperform those focused on the double bottom line. One reason is due to the growing demands and desires of personalised items, and more consumers are seeking more active ways to influence and participate in the design cycles of production. The varieties and choices of products, particularly under globalisation, have significantly increased for consumers, and growing ubiquity of platform services and mobile applications continue to create

niche demands. Customisation of products is not restricted to only cosmetic designs. To clarify, customisation as discussed has always been part of consumer needs, but it differs from highly personalised products and handcrafting. Scale customisation is to achieve a state in which mass production value is maintained with customisable product offerings to consumers. With integration of digitalisation of product and service together, this presents new opportunities for designs and manufacturing to cover broader ranges for niche markets.
For example, Hong Kong has very high density of population in small confined spaces, therefore multi-functional and compact products satisfy the specific environmental constraints. Mass furniture manufacturers like S&C Furniture Limited in Hong Kong, and even global giants such as IKEA, particularly created line of modular products to cater to this niche market. By leveraging augmented scan of housing environment, these furniture manufacturers can understand home usages and conditions in pre-production cycles, resulting in better designs and fitting for their customers.

About S&C Furniture Limited
Being one of the pioneers and leaders of the Hong Kong furniture industry, S&C Furniture Limited is devoted to develop products that evolve with technology and most importantly Hong Kong's local living habitat. S&C is dedicated to develop a smart customisable furniture system that allows better understanding of clients, in order to customise unique furniture modules for each unique home using acquired data and algorithms.

On another spectrum, startup communities have been approaching the market radically. unspun, inc., a startup team comprised of garment experts and technologists, is using full body scanned system to custom tailor make 3D printed jeans. Meanwhile, they are also inventing their own 3D textile machines to further reduce the cost and time for production.

About unspun, inc.
unspun is a venture-backed robotics and apparel company, building custom jeans for each consumer, on demand. Its mission is to reduce global carbon emissions by at least 1% through automated, localised, and intentional manufacturing. unspun is a fast-moving company powered by technology, the National Science Foundation, SOSV, the Mills Fabrica and the H&M Foundation.

New generation consumers have been constantly nurtured as designers. With the emergence of makerspaces, communities in DIY crafts and production have been revitalised. TML, or To Make Locally, a Hong Kong based co-creation hub established with small-scale production facilities, is a prime example providing resources and incubation in this space.

An interesting phenomenon is the gaming industry and open social platforms in enabling consumers to become creators, and this culture has permeated across other sectors. Popular games such as Minecraft allow users to develop structures and architectures from scratch, platforms like Etsy enabled general consumers to access artisan products from home, social platforms like YouTube allow each user to profile their own subscription channels for video viewing, and there are countless more across diverse marketplace enabling personalisation needs.

With consumers more and more involved in the design process, consumers will no longer play a receiving role in the market. The sense of involvement for consumers creates higher sense of attachment and pride rather than just consumption. Engaged communities become collaborators of the whole culture in shaping the products in which they like to use and purchase. The intertwining of personalised technologies in digital space and customisable artefacts in physical space will create

ripple effects, progressively cultivate and empower consumers' behaviours in personalisation and customisation.

About TML Apparel Limited

TML (To Make Locally) Apparel Limited is a one-stop smart manufacturing base that combines collaboration, production, technology and sales. It has been established as a "Hong Kong Made" brand with end-to-end service value chain. While maintaining financial balance, the initiative also strives for social values. This balance is critical in ensuring business diversities and sustainability in growth.

One of the researched design team in Hong Kong, Memomem Limited, partnered with Swiss watch manufacturing experts, has successfully portrayed the essence of consumer as designer by leveraging scale customisation capacities. From 100% handcrafted and custom-made Swiss watch, the team blended high quality technologies to turn premium luxury into common affordable products for mass market. With over 17 quadrillion possible combinations, every part of the watch can be customised transparently, from colour options, texts, bezels, cases, dials to hands, resulting in 17 quadrillion possible combinations in styles. The digital design portal enabled consumers to order online directly from the manufacturer. With higher data transparencies to consumers' preferences of styling, the team was able to better predict design styles and to manage inventory level at minimum.

About Memomem Limited

Memomem was founded by the post-90s Hong Konger Jims Liu. With the experience and knowledge of the 3 generations of family watchmaking, he has turned the 100% handcrafted, custom-made, "Swiss Made" product with high-quality technologies into a common item. To Memomem, a watch is not only a time instrument but also a life essential to represent ourselves, to mark every moment, and to create memory.

Figure 13
Memomem features over 17 quadrillion possible combinations in watch styles

3.6 Take Me Somewhere Nice

The changes in Relationship alters the position in which one approaches the subject.

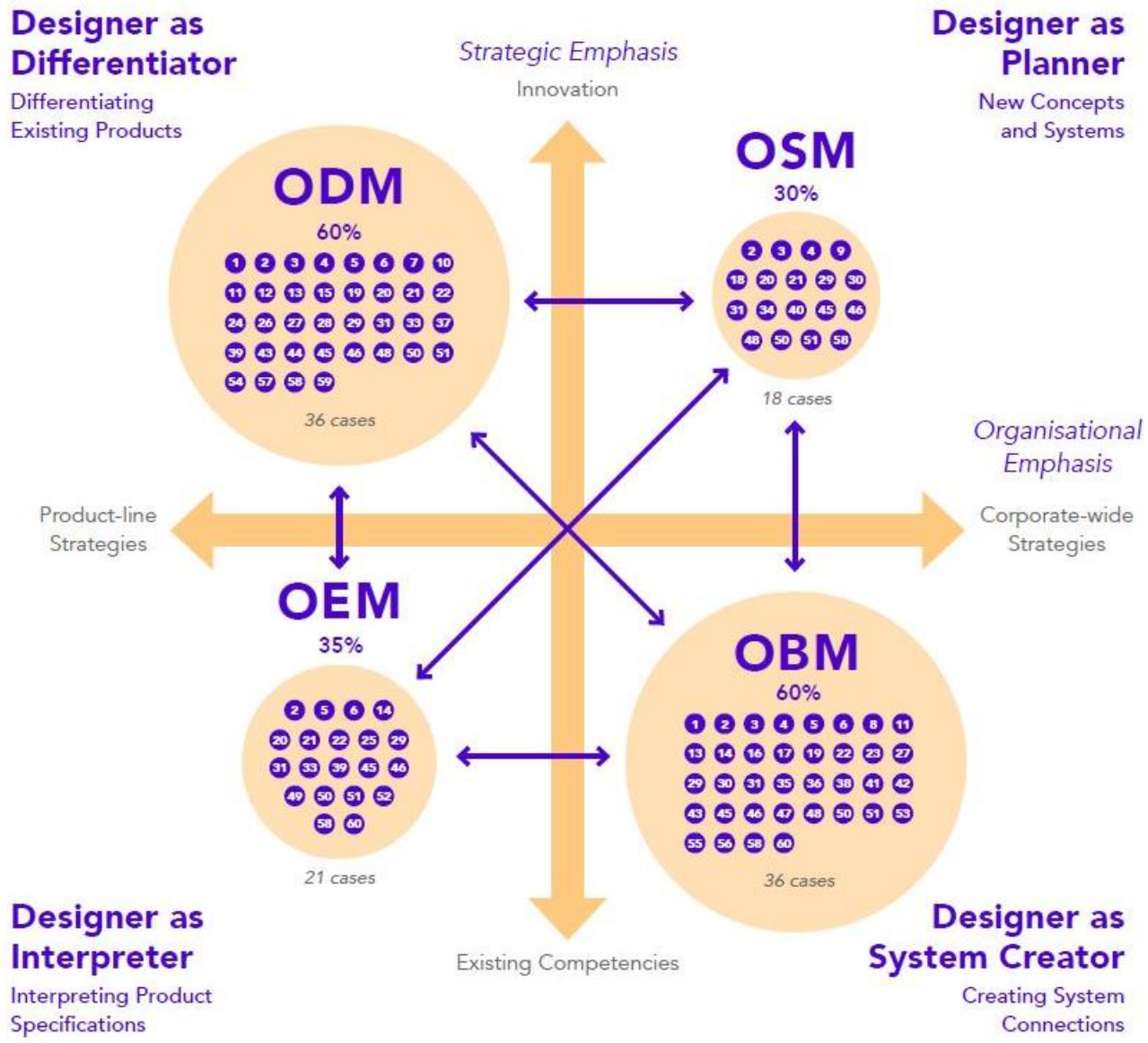
With the changes in consumer demands, the design of products also needs to change. Smart technologies have enabled physical artefacts to have digital interfaces. For example, smart chairs and tables allow remote control functions on housing electronics. Shoes can be 3D printed and customised with insoles and designs. Clothing becomes wearables just like smart watches. Cars become connected with added values extending beyond its physicality. One may think that these are just added technologies to physical objects, but much greater values are generated with these enabling technologies to capture real data and usages from end consumers.

Manufacturers and designers have long relied on sales and trend reports to gather indirect insights on consumer markets. The possibilities when manufacturers can directly obtain information from their respective consumers create more accurate quantities and designs in alignment to real user needs. To an extreme, disintermediation through removal of intermediaries, such as distributors, wholesalers and brokers, may even be resulted as new manufacturing business model.

With high transparencies to market, manufacturers can further strengthen their strategic offerings from business-to-business to business-to-consumer. With e-commerce, consumers can now directly purchase from factories (the concept of factory direct) while becoming less dependent, or even bypassing, wholesalers and retailers.

Through research, many Hong Kong manufacturers and designers have expanded their OEM (product and production driven) foundation to ODM (design driven with integrated manufacturing capabilities), OBM (service driven) and even OSM (design as strategy). Over 50% has developed their own branded product lines (OBM) from OEM business model, or has positioned their business operation with design-driven capabilities (ODM); whereas prioritising design (OSM) as business strategic pillars only tally to under 9%. While this aligns to the economic growth in Hong Kong as tertiary sector driven, these designers and manufacturers have identified the importance of customer values as market forces in prioritising their organisation strategic growth, from product to service-driven.

Figure 14
The OEM-ODM-OBM-OSM model in relation to the role of designers[11]



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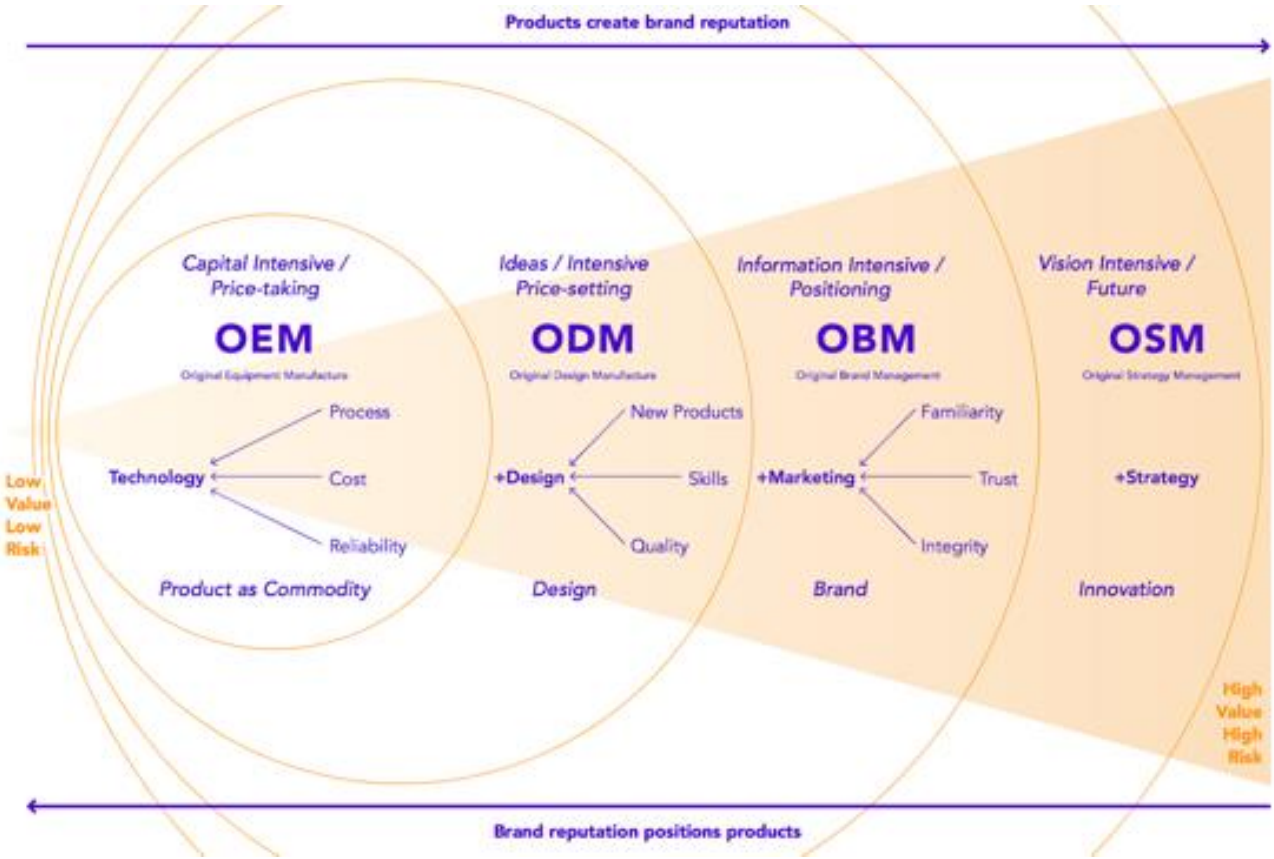
[11] Heskett, J (2003). "Different levels of design practice." *Shaping the Future: Design for Hong Kong: a Strategic Review of Design Education and Practice*. School of Design, the Hong Kong Polytechnic University.

Figure 15
Different levels of design practice[12]



[12] Heskett, J (2003). "Different levels of design practice." *Shaping the Future: Design for Hong Kong: a Strategic Review of Design Education and Practice*. School of Design, the Hong Kong Polytechnic University.

4. The Departed

With 70 local manufacturers and designers interviewed, there are several insights drawn which created the paradox and conflicts between their roles.

AT A GLANCE

THE SITUATION
Industrial designers and manufacturers have conflict of interests. Traditional manufacturing landscape is structured as hierarchical (zero sum game) instead of integrative (win-win) between the parties. As a result, some become winners while others struggle in the competitive space.

WHY IT HAPPENS
There are several factors that constitute the paradox among designers and manufacturers.

1. The “Born” Identity
2. Gone North
3. The Not-So Great Gatsby
4. The Day After Tomorrow
5. Already Tomorrow in Hong Kong
6. Bad Education
7. Robopocalypse

THE IDEAL
In a harmonised relationship, designers and manufacturers need to have transparent communication, such that decisions are achieved through mutual cohesion. It requires co-design and co-manufacturing processes instead of linear transition of tasks. A win-win relationship needs to be cultivated such that the identities can be strengthened together.

4.1 The “Born” Identity

Through research analysis with multiple Hong Kong Industrial Design Professionals, their design approach heavily inclined towards aesthetics and usability of products, with limited exposures in manufacturing capabilities, technologies and business dimensions. On the other spectrum, Hong Kong OEM manufacturers have high degrees of control and ownership in manufacturing technologies and processes (technical-driven and business-driven), which shapes the overall strategies and organisational development. Although many manufacturers may not be design-educated, they must consider all spectrum of design strategies as key business drivers. Suppliers also provide design requirements and OEM manufacturers follow specifications to production. This also extends the roles of manufacturers to design and branding activities as their businesses scale up. The nature of this model limits the necessity to have in-house design capabilities, causing bigger disconnect of knowledge to Hong Kong industrial designers. The priority of concerns in manufacturers’ lens continue to widen against local designers.

Research has shown that over 70% of Hong Kong manufacturers have little knowledge to understand the capabilities and true values of industrial practices, resulting in generalisation of industrial designers to be associated with just decorative, cosmetics and styling activities. This is particularly true when the leadership and management team has limited exposure to formal training in design principles and management. The identity crisis with industrial designers, in irony, are familiar like Information technologists to be generalised as computer technicians. Although Hong Kong industrial designers reflected their high level of passions and knowledge towards aesthetics and design methodologies, very few of them demonstrated understanding of manufacturing processes and systems in modern technologies.

Commonly, local industrial professionals claimed themselves to be product design professionals, as if the prefix of industrial added an extra level of complexity towards their profession. As industrial designers cannot fulfil the roles to apply innovative thinking to breakthrough designs in solving many business challenges in the competitive space, manufacturers as business owners began to source external knowledge, e.g. through exhibitions, trade shows, vendors, workshops, etc, to increase their own understanding of new trends and technologies. This result in manufacturers' objectives prioritised to heighten and increase value in their products and services. Meanwhile, many industrial designers are fixated on enhancing product features and design through aesthetic changes. As more and more product designs and production steer in one direction, this widens the gaps in Hong Kong industrial landscape, causing many 'dead-end' solutions.

THE RESEARCH

Based on the Stanford d.School design innovation framework, the Centre for Design Innovation expressed it as 6 spectrums of industrial innovation:

Translating our research statistics into this framework, one can examine the areas of interests of Hong Kong manufacturers and industrial designers, as well as their active roles and responsibilities.

THE OBSERVATION

In Hong Kong, manufacturers have a broader spectrum of innovation interests than industrial designers. Organisation behaviours and technological development, which are critical factors of success in strategic progression in Industry 4.0, are rated very low for designer roles. Ironically, an

industrial designer by education and training should be able to cover all spectrums and provide valuable insights to manufacturers for strategic breakthrough.

Figure 16
Manufacturers' orientation

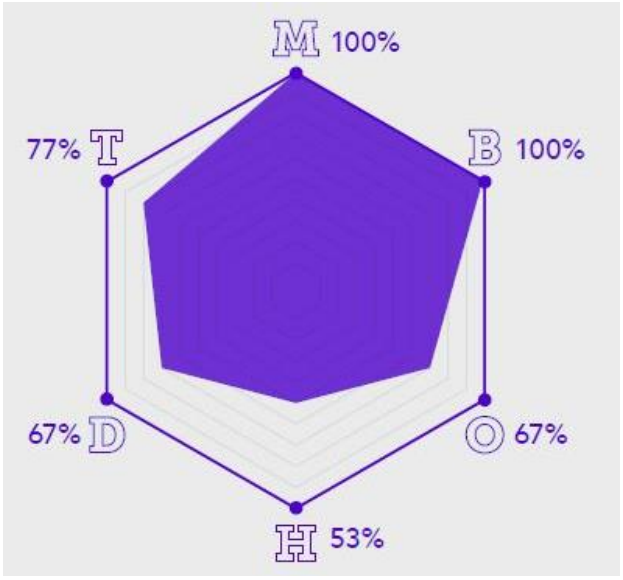


Figure 17
Industrial designers' orientation

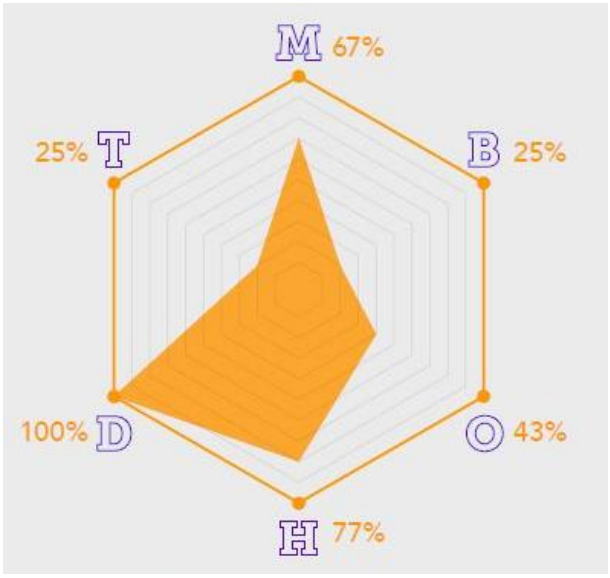
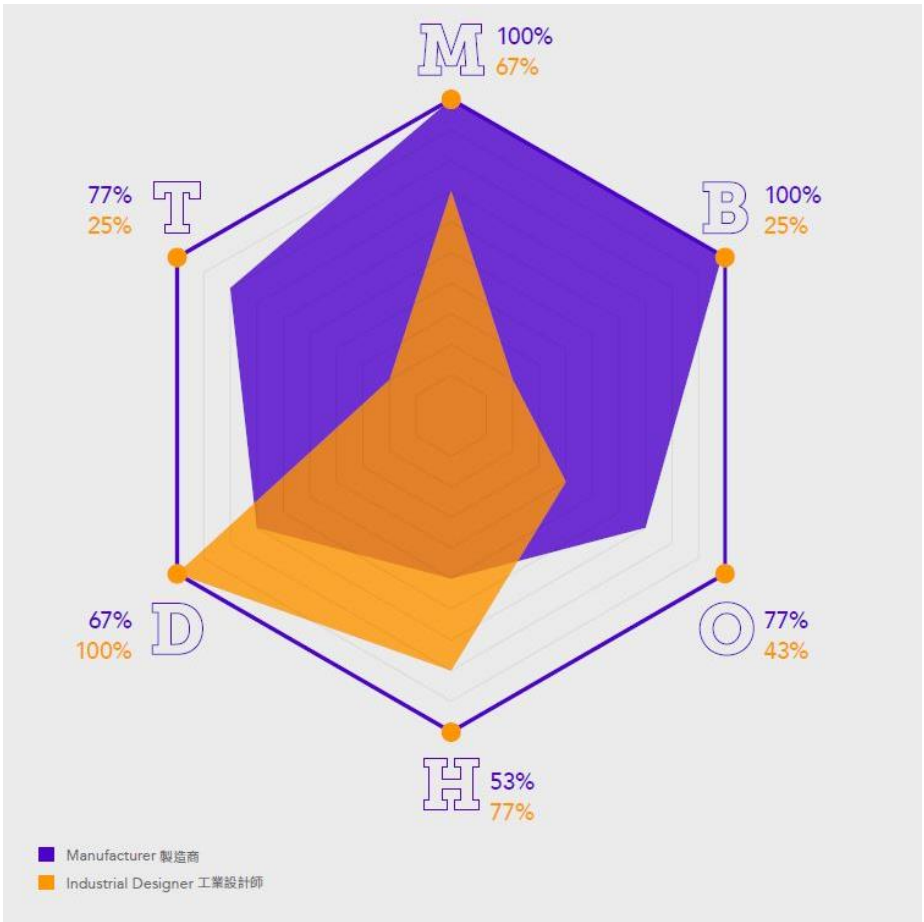


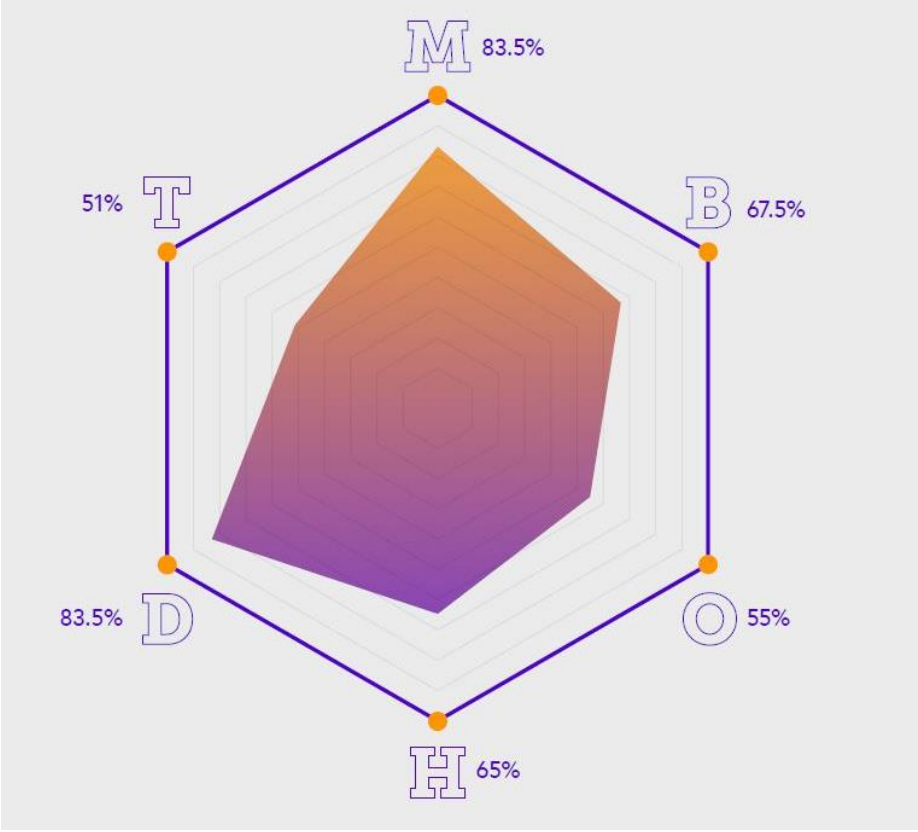
Figure 18
Separate orientation – the gap between the interests of manufacturers and industrial designers in the innovation spectrum



With the changes occurred in Hong Kong manufacturing landscape, the area of focus, as commonly shared by all manufacturing leaders in the research, is to evolve the business strategy in alignment to the changes taking place in the production technologies. Without a doubt, traditional manufacturers continued to strive to further production capacities and business operations, while the new generation of manufacturing leaders seek to expand the scope from product to service strategies.

Designers who lead and operate in manufacturing settings demonstrated their respective abilities and high interests in product design and interactivity. Although design with human experience has always been an essential of product and system designs, only 50% of the industrial designers interviewed prioritised human values as fundamentals. Majority of designers are keen on aesthetics and appearance of their design; technological and business considerations were particularly low, leading to bigger gaps between manufacturers' priorities against designers.

Figure 19
The combined orientation balancing interests of manufacturers and industrial designers in the innovation spectrum



Instead of pulling away, manufacturers and designers seek to lessen the gaps to compliment respective values and skills. As calculated in the combined orientation, technological and organisational capacity development score just averaged past the 50% margin. Without appropriate support systems and infrastructures, this hinders the knowledge and change capacity for an organisation to meet the small batch production demands in this disruptive and transformative digital era.

4.2 Gone North

Although manufacturing underwent a booming period in the past, many factories have migrated away from Hong Kong locally to the north. The removal of the physical infrastructures resulted in a disconnect, or a knowledge blank period, in Hong Kong manufacturing landscape after the migration.

Furthermore, manufacturing and product design knowledge were once obtained through apprenticeship. While many manufacturers did not receive formal education in design methodologies, they honed their skills through hands-on practices. As manufacturing environment diminishes, next-generation industrial designers in Hong Kong have less opportunity to access and understand the development of manufacturing systems and infrastructure settings.

4.3 The Not-So Great Gatsby

As Interviewee E stated, "Manufacturing investment strategy is dependent on real estate (buying lands in underdeveloped areas) and low cost of labour for production."

What about manufacturers who strive for other competitive edge?
"Government funding and external investment channels becomes a critical outlet."

Hong Kong economy is mainly driven by real estate and financial sector. Upon interviews with Hong Kong industrial leaders, questions and concerns were raised to understand their strategic positioning in expansion of their manufacturing businesses. Similarly, the manufacturers have furthered their business scopes to real estate and financial investments, and their OEM operations become sub-entities to parent corporations. This reduces the anxiety and pressure for the manufacturing capabilities to evolve as the core business no longer relies on manufacturing production alone.

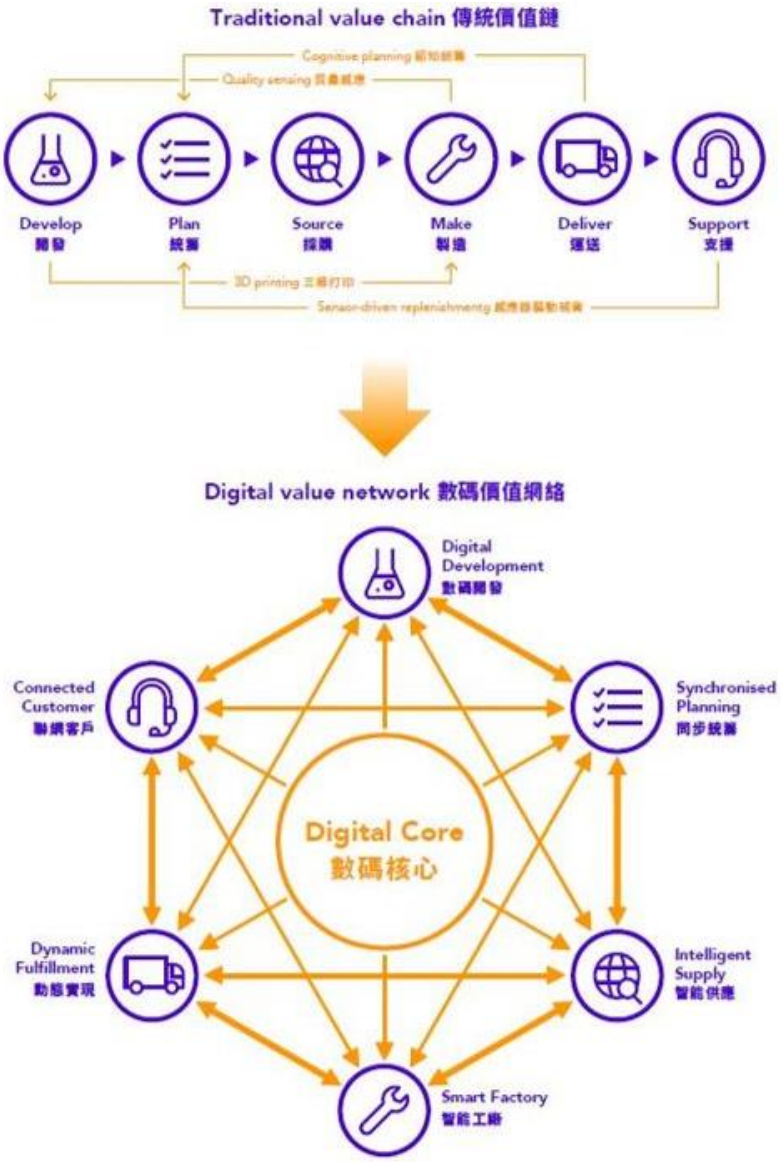
On the other hand, some Hong Kong manufacturers who depend solely on production business have to transform by meeting this new economic shift - in both customisation and using industry 4.0 technologies - and to not fall behind in this competitive space. These OEM manufacturers are not only competing locally but against global giants and other established corporations that began to expand their service scope, e.g. Google can manufacture driverless cars. The transformation becomes inevitable to increase OEM service value. The latter, however, experience great challenges in organisation changes.

One of the main reasons are financial constraints as they do not have the necessary capital to pre-invest and wait for years of return. The dilemma of shifting limited capital to invest in scale customisation equipments can easily lead to their pitfalls and affect their foundational OEM business. Through research, some of these owners indicated the importance of government funding schemes in matching their limited investment pool.

4.4 The Day After Tomorrow

For decades, manufacturers have been focusing on developing capacities to captivate on costs for productions, with the belief of increasing product qualities and added functionalities while lowering prices to maintain competitive edges. While this model has been effective in the past, it was built upon the conditions with long production time and distance, and the opportunity space to capitalise on the profit gain was to optimise the gaps in between. With technological advancements, the gaps in the production life cycle have shrunk dramatically, and new windows of opportunities are resulted. The old strategy is now constantly being challenged as the world becomes more globalised and fragmented, distributions will become faster and easier, consumers expectations will continue to grow, and large quantities with small profit margins cannot sustain the growth and even survivability of manufacturing businesses.

Figure 20
The transformation from traditional value chain to digital value network[13]



[13] Deloitte. (Dec 2016). The rise of the digital supply network. Retrieved from https://www2.deloitte.com/insights/us/en/focus/industry-4-0/digital-transformation-in-supply-chain.html..html

4.5 Already Tomorrow in Hong Kong

Information technologies heavily influence the survival and future of industrial space. With technologies integrated into people's daily lives, consumers will become more connected to information at high speed. Progressively, consumers develop quicker habits to sift through information and only engage in products and services that align to their best interests. This fundamentally transforms consumers expectations and behaviours, creating a need-driven culture. Speed of manufacturing, variety of design choices and ease of accessibility to products will become crucial success factors, and neither one can be exclusive from one another. This poses challenges for designers and manufacturers to respond adaptively and quickly with legacy systems.

Traditional methods using post-sales analysis reporting and market researches are insufficient to keep up, and so, Industry 4.0 technologies stresses on real-time data monitoring to progressively capture live user movements for predictive forecasting. Although the application of advanced technologies is inevitable in the upcoming industrial transformation, a subset of Hong Kong manufacturers and designers do not see technology as a strategic pillar to progression. Many view technologies as purchases off the shelves, just like retail consumer products. They tend to wait for solutions to be fully mature when market has commonly adopted the technologies instead of strategically planning ahead of the curve. This results in passive actions instead of proactive approaches.

The economy has already advanced from the industrial era to the knowledge era, where technologies and information denote economic progression, and many Hong Kong manufacturers shown minimal signs of knowledge with technological skills. Cost of manufacturing systems are high and not easily upgradeable without transformative infrastructure changes and knowledge training. The lack of knowledge in technological utilisation also constrain available options to make progressive upgrades without disrupting existing operations and finances.

Exception

One exception identified amongst the researched manufacturers in Hong Kong is Best Victory. With leadership roles trained in computer programming, engineering and business background, they were able to transform from paper documentation and analogue controllers to full extensive usage with Industry 4.0 technologies. As they claimed, the technological transformation to uplift the deep-rooted legacy systems and processes was made possible due to their thoroughness of technological knowledge and analytical mindsets.

4.6 Bad Education

With the ever-changing environment, traditional knowledge and training methods have become a hindrance. Currently, Hong Kong manufacturers and designers have to undergo at least 12 to 18 months to adapt to the changes and see fruitful results on organisation level when applying new system upgrades. Meanwhile, education systems in Hong Kong still lack in incorporating the new mindsets and latest technologies to train next generation industrial designers - in response to the growing demands in customisation and technological changes in manufacturing. This creates further gap in meeting manufacturing owners' needs to ride on industrial designers' knowledge in attempt to reshape their business changes and growth.

Meanwhile, many local universities in Hong Kong has restructured industrial design in bachelor programmes into product design in major. Although there are master degrees on design management, the marketspace has become limited and fragmented to appeal to mass public as career paths. Upon research with design students, many of them indicate their lack of manufacturing knowledge and so they have to hone their skills on aesthetic designs and ergonomics, and there is a lack of opportunities to move up in career. In turn, many designers aim to become entrepreneurs - with own brand - to pilot their own designs and projects in hopes for better future.

Opportunities

Institutions like Vocational Training Council (VTC) in Hong Kong has recently partnered with Hong Kong Productivity Council (HKPC) and Fraunhofer IPT to launch new programmes, with hands-on training, specifically on nurturing next generation designers on Industry 4.0 capabilities.

4.7 Robopocalyse

Another rationale reflected upon research is the deskilling of labour and knowledge workforces. Traditionally, workers have been dependent sources of intervention with machine operations in manufacturing, while designers play active roles in leading design criteria for production. As technologies advance in manufacturing space, the relationship of design to product and workers to machines are being redefined. Full automation undermines the necessity of human labour in manufacturing environment and replaces routine activities with robots, and digitalisation leads to remote control and operations of production. Consumers are taking more active roles to demand designs of products, adding levels of complexity and conflicts with designers' own perceptions of product aesthetics and design feasibilities. The deconstruction of roles and responsibilities changes the dynamics in which workforces are distributed and assigned in the organisation, and places the career of many industrial workforces at risks.

5. Lot of Details, Half the Retail

5.1 Wisdom of the Crowd?

"Hong Kong is heavily populated in close proximity, whether it's residential or commercial retails. This means that everyone can easily access products and services of any choices without much need to seek for personalisation. If the person cannot find one thing, he/she can just walk next door and shop."

According to industrial design professional F.T, he shared his view of Hong Kong market landscape: "Hong Kong is heavily populated in close proximity, whether it's residential or commercial retails. This means that everyone can easily access products and services of any choices without much need to seek for personalisation. If the person cannot find one thing, he/she can just walk next door and shop." This phenomenon may be true in metropolitan cities with highly-dense population, particularly for Asia Pacific cities like Hong Kong. However, it is also due to the diversities of products and multicultural communities in close proximities which enable such consumer behaviours. Further on this rationale, many retailers based off their strategies on geographical benefits, located in high foot traffic neighbourhoods while operating in brick and mortar environment. Alongside with competitive pricing, quality of products and in-store experience, retailers can maximise their profit gains and retain consumers' loyalties. This can only be possible in highly populated communities.

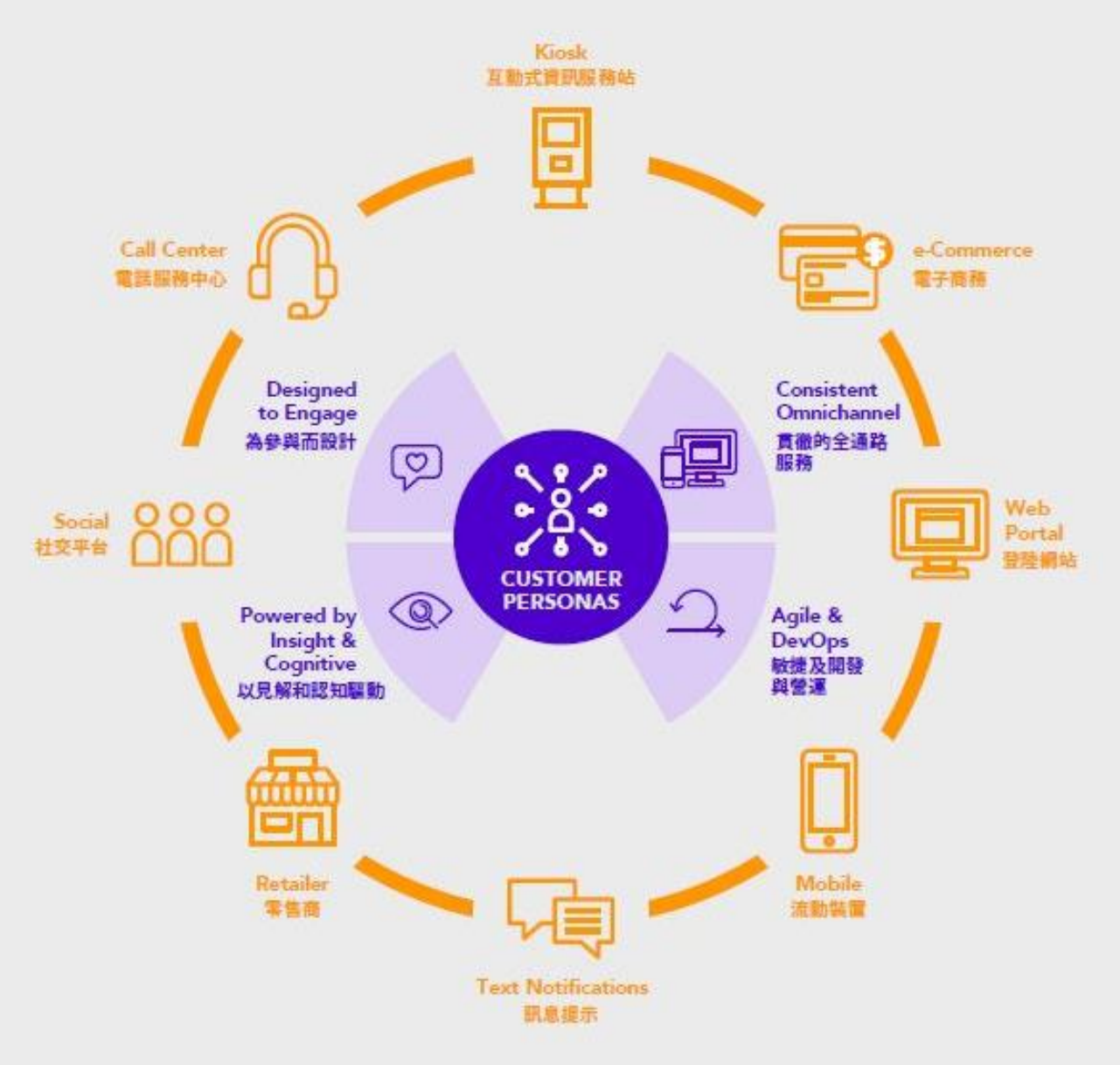
5.2 Confessions of a Shopaholic

As per research statistics from this project, the once high percentage of sales for omni-channel retailers in the offline world is dramatically shifting towards online mediums. Some have increased online sales from under 10% to 30%. Design factories such as OFESS have even furthered social media channels as consumer engagement strategy to drive product interests and designs. New generation consumers will continue to browse online for competitive prices and for information, such as user reviews and descriptions on consumer goods, and global shipping has become far more accessible due to globalisation. Fewer and fewer consumers will access physical stores to make their final purchases.

OFESS
A "design factory", which provide both design and manufacturing services on premium gifts and toy collectables. With multiple award-winning designs and original product lines, OFESS has expanded their business scope from design and manufacturing to brand and consumer management.

Omni-channel Retail
A unified experience supported by omni-channel approach, which includes channels like marketing, advertising, digital platforms (web/mobile), service centres (call centre), brick and mortars (in-store) and more. Consumers should experience consistent brand messages and identities which translates across all distribution channels.

Figure 21
An illustration on Omni-channel Retail processes[14]



"Offline sales are progressively shifting to online mediums, and it is becoming easier for consumers to make purchases globally."

"Leading retailers are shifting from physical experience to digital, and sales has increased 6 to 7 times due to higher consumer engagement."[15]

With the growing challenges in brick and mortar environment, retailers seek to revamp physical engagements, and thus the concept of "retail as destination" emerged. For example, Rebecca

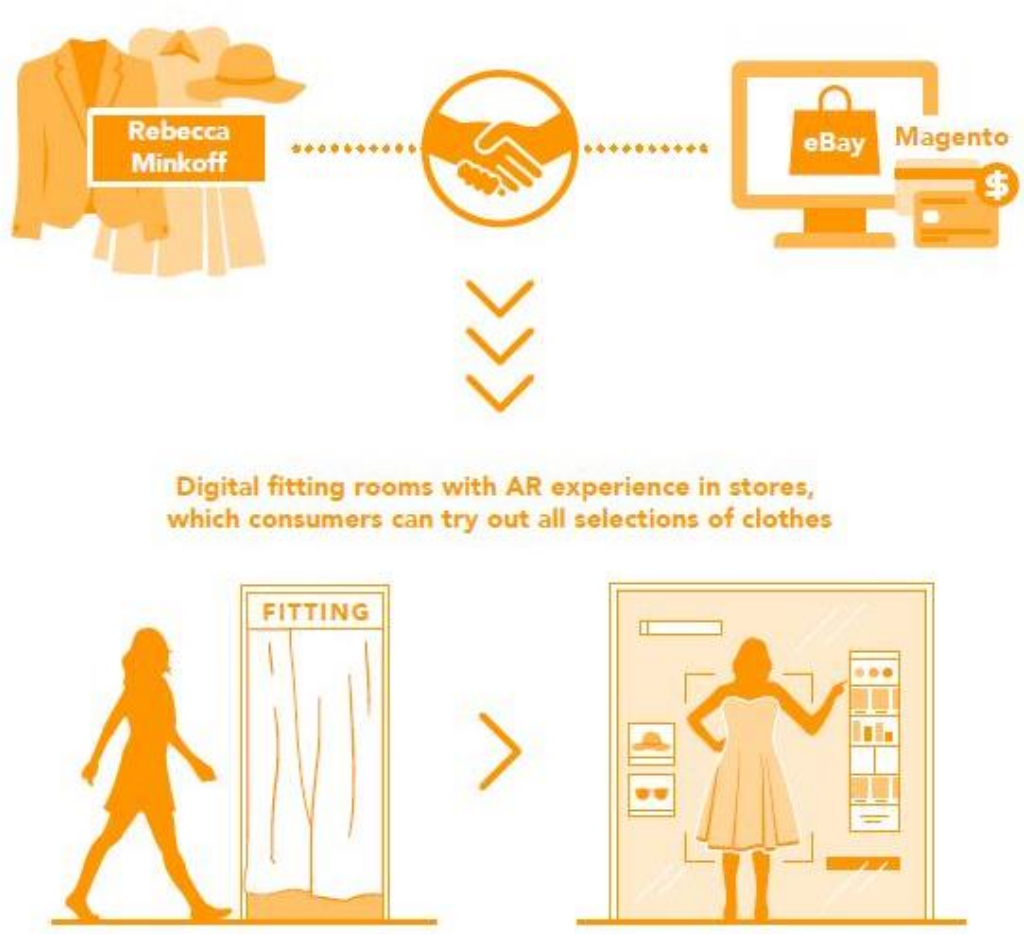
[14] Anderson, Dawn (n.d.) "Seamless Experience across Channels", Omni-Channel: *Winning the Experience Battleground*. Accenture. https://www.accenture.com/lv-en/service-omni-channel
[15] Google. (2015, October). Rebecca Minkoff Empowers Millennial Shoppers. Retrieved from https://www.thinkwithgoogle.com/intl/en-145/success-stories/global-case-studies/rebecca-minkoff-empowers-millennial-shoppers/

Minkoff, a global luxury clothing brand, partnered with eBay and Magento to innovate their in-store experience[16]. The engagement gap was bridged with augmented reality, creating digital fitting rooms in stores which consumers can try out all selections of clothes. The sales increased by six- to seven-fold after the project piloted.

With digital tools and systems intermixed in physical and digital space, the experiential designs can continue to evolve endlessly. Shopping experience is no longer confined to physical space but instead boundaryless within the digital realm. Retailers seek to integrate their digital data with manufacturers, designers, and other stakeholders, thus forming a digital supply network to achieve horizontal integration in the production value network. Smarter and connected systems result in high transparencies of sales and usage data, providing a more inclusive and holistic consumer experience.

Rebecca Minkoff is a global brand with a wide range of apparel, handbags, footwear, jewelry and accessories (including tech) as well as men's accessories under the label Uri Minkoff. In the spring of 2017, Rebecca Minkoff Watches was launched, reimagining the category through their decidedly downtown, Rock and Roll aesthetic.

Figure 22
Rebecca Minkoff partnered with eBay and Magento to innovate their in-store experience



[16] World Economic Forum. (2017, January 15). Shaping the Future of Retail for Consumer Industries. Retrieved from https://www.weforum.org/reports/shaping-the-future-of-retail-for-consumer-industries

5.3 Sense and Sensibility

The key of retail transformation to achieve higher operational efficiencies and customer loyalties are not just dependent on sensible aspects like technologies, but also the humanistic approach such as the mindsets of collaborative approach with partners, stakeholders and even consumers. While retailers are sole experts in in-store experience delivery, the brick and mortars are only interfaces to consumer experience, and the success to the next future of retail can only be made possible with forward thinking in the business design strategies, while leveraging digitisation with mobile, cloud and service platforms. One can further examine the various retail business models[17] which emerged since Industry 3.0 shifted to 4.0.

The lines of manufacturing, design and retail are crossing, and the intermediaries along the supply value chain continue to collapse. The cycle times of information flow between the three stakeholders need to communicate with consumers more timely and accurately. This has heavy implications on value creation to consumers. Production is no longer simply manufacturing great products on shelf. Manufacturers and designers need to step out to the frontier, to capture real-time user feedbacks, thus improving the consumer experience in selection of purchase with new ways. With consumers driving the market, SME designers and manufacturers can further adopt scale customisation strategy, particularly with build-to-order approach, high collaboration to design process, and rapid iteration of prototype to production to penetrate and gain market competitiveness.

Figure 23
The evolution of new retail business model (when scale customisation design strategy meets with Industry 4.0)

Model	Description
Subscription model e.g. Netflix	Retain and lock-in consumers by charging subscription fee, generally on monthly basis, for continued access to product/service
Freemium model e.g. MailChimp	Offer free first tier level product/service as “teasers” with the trade-off of money to obtain consumers data, subsequently hook onto consumers interests to make further upgrades and purchases
Free model e.g. YouTube	Harness and capture consumers’ interests in free experience of goods and services, and harvest consumers usage data
Marketplace model e.g. Etsy	Digital marketplace which connects buyers and sellers directly, charges transactional fees or commissions
Access-over-ownership model e.g. AirBnB	Share economy concept; charges commission or usage fees from people monetising their assets through sharing/lending to temporary consumers

[17] Jo Caudron and Dado Van Peteghem (2015), *Digital Transformation: A Model to Master Digital Disruption*, Duval Union Consulting.

Hypermarket model e.g. Walmart	Brand bombing
Experience model e.g. Niketown	Superior experience in which consumers are willing to pay premium for
Pyramid model e.g. Shop	Leverage small-scale resellers and affiliates to drive revenue
On-demand model e.g. Uber	Services and products which are offered with instant access but priced at premium, bridging the gaps between “people with money but no time” and “people with time but no money”
Ecosystem model e.g. Alibaba	Products and services that are connected to larger ecosystems, which increases in value in time and usage; creates consumer dependency

6. Ender's Game: Scale Customisation as Manufacturing Design Strategy?

6.1 Mass Effect

Among conversations with many Hong Kong designers and manufacturers, there are confusions and misunderstanding that customisation is to design and manufacture separately for each and every individual consumer - this is another concept discussed in many Industry 4.0 studies as "batch size one" and mass personalisation.

Customisation is not a new term. To clarify the misconception of scale customisation and personalisation, one can study from the industrial approach with customisation as strategy. The concept was popularised in 1993 by Pine et al's Harvard Business Review article[18], and some academic studies even traced back to 1980s. To clarify, scale customisation aims to deliver products and services that best cater to consumers' needs with close to mass production costs and efficiencies. The straightforward definition of scale customisation was "producing goods and services to meet individual customer's needs with near mass production efficiency" by Stan Davis (1987). Lately, Kaplan & Haenlein (2006) and McCarthy (2004, p. 348) have highlighted the strategic balance between creating the customised products and maintaining the capability of mass production. The equipment allows low volume production and prototyping, while the feasibility of mass / scale customisation always entails the mindset of the leader, management and knowledge workers.

One principle which differentiates scale customisation from mass production is consumers' active involvement, by incorporating consumers' identities as inputs to design and service delivery in the value creation process of production. Another important theory is switching from economies of scale, which entails maximising gains through large volume production, to economies of scope, which focus on expanding benefits to produce wider ranges of products efficiently under the same infrastructures and business activities.

One can further study and compare the strategic objectives between mass production and customisation through the modified research conducted by University Technical Malaysia Melaka[19].

[18] Pine, B.J. (1993). "Mass Customization: The New Frontier in Business Competition." Boston, Mass., Harvard Business School Press.
[19] Nair, S.K., Thakur, L.S. and Wen, K. (1995). "Near optimal solutions for product line design and selection: beam search heuristics". *Management Science*, 41(5), IGI-I'&S.

Figure 24
Mass Production vs Mass Customisation, modified from Thakur et al. Mass Customisation

Parameters	Mass Production	Mass Customisation
Goal	Deliver standardised goods/services with low price	Deliver varied goods/services to fulfill specific customer groups with different wants/needs. Try to offer a lower unit cost
Economics	Economies of scale	Economies of scope with customer integration
Focus	Efficiency through large volume production, stability and control	Variety through personalisation, flexibility and responsiveness
Key features	Stable demand, low cost, consistent quality	Fragmented demand, mid-high cost, specific quality
Customer involvement	Passive	Active

6.2 Margin Call

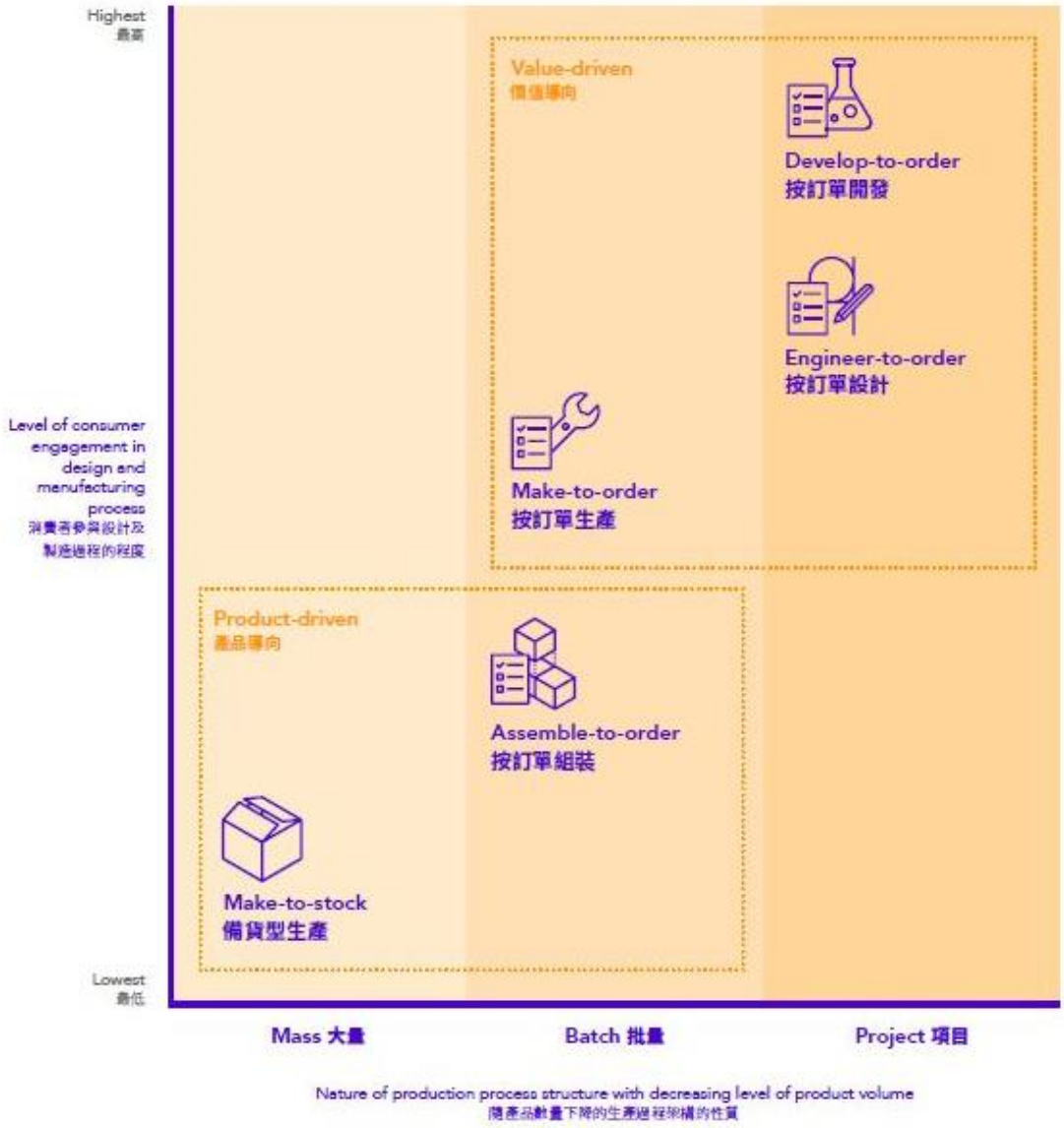
Customisation as a strategy is particularly suitable for small to medium manufacturers to target niche markets. SMEs have competitive edges as they are more adaptive to changes and closer to consumer engagements, while larger manufacturers require more resources to reposition themselves in the market.

Given that designers and manufacturers goes hand-in-hand, to approach scale customisation strategically, the involved stakeholders should understand the dimensions of production systems synergistically. The five types of customisation approaches, according to Wortmann's typology, demonstrate the relationship between design to manufacturing process structure, product volume and consumer involvement.

According to S&C, furniture as design can be approached with all five types of customisation systems for manufacturing. Similar with toy design manufacturers like Maisto, OFESS and Yick Shun Group, watch companies as Memomem, and others, products which can be designed and developed by parts are in particular favourable with assemble-to-order approach.

These businesses commonly shared the modularity in their product designs and assembly, achieving a higher degree of flexibility in approaching customisable products manufactured in scale - from batches to mass volumes. To further understand the benefits and differences of customisation occurring in each system, one should further examine the approach that best fits their organisation development stages and capabilities.

Figure 25
The nature of production process structure in relation to the level of product volume and consumer engagement



The Theory of Customisation Strategy

The theory of customisation strategy can be also studied through Wortmann's typology[20], which is categorised into five types of customisation production systems:

1. Make-to-stock (mass produced to stock)
2. Assemble-to-order (mass produced by parts and assemble to order delivery)
3. Make-to-order (manufacture to order)
4. Engineer-to-order (design and manufacture to order)
5. Develop-to-order (research, design and manufacture to order)

[20] Wortmann, J. C. (1989). *Towards an integrated theory for design, production and production management of complex, one of a kind products in the factory of the future* ESPRIT '89: Proceedings of the 6th Annual ESPRIT Conference, Brussels, November 27 - December 1, 1989, pp. 1089-1099, 1989. Retrieved from

In make-to-stock customisation approach, products are mass produced with customisable features or integrated technologies and stock in large volumes. The difference of this to traditional mass production system is that the concept of customisation is defined as early as the design stage, and this maximise the benefits of mass production capabilities while the flexibility of the product design provision consumers to specific individual needs. At the same time, manufacturers have to bear the overhead of high inventory management and controls.

Assemble-to-order prioritises on production by parts, and assemble the final products after consumers placed their orders. The significance lies in manufacturing resource planning and forecasting to ensure every modules and parts are readily available, and modularity of product design becomes essential. Modular products achieve economies of scale through mass production of product parts rather than the products themselves. Such can be seen in Memomem watches and S&C nano-home furniture series.

Make-to-order customisation initiates the manufacturing process after consumers orders are placed. This is approach particularly common in the computer industry, where products can only be produced and configured after consumers personalised their purchase. Zotac Hong Kong, a leading OEM computer chip manufacturer, utilise parts of this approach for their new line of gaming products.

Engineer-to-order customisation goes with meeting customers' specifications through production cycle starting from design activities, manufacturing then logistics. The focus of this approach is that consumers already have design specifications in mind, so rather than heavily relying on design efforts, product feasibility is materialised through engineering practices.

Develop-to-order has the highest degree of consumer engagement throughout the production value chain. Typically, consumers only have vague concepts to the solutions they desire, and so they sort for design and manufacturing capabilities by initiating research development. The production cycles tend to be lengthy due to heavy research and prototyping processes.

6.3 The Incredibles

Beyond the different adoption of design to manufacturing approaches reflected upon research, the business model driven by new industrial design development to meet customisation demands has also shifted drastically. A concept such as Product-service system, a.k.a. PSS, has emerged in the past years to meet the paradigm shift[21]. According to Piscicelli, L., Cooper, T., & Fisher, T. (2015)[22], this system model involves an inclusive design and delivery of products and services. PSS models

https://www.researchgate.net/publication/299888769_Towards_an_Integrated_Theory_for_Design_Production_and_Production_Management_of_Complex_one_of_a_Kind_Products_in_the_Factory_of_the_Future

[21] Cees Van Halen; Carlo Vezzoli; Robert Wimmer (2005). Methodology for Product Service System Innovation. Assen: Uitgeverij Van Gorcum. p. 21. ISBN 978-90-232-4143-0.

[22] Piscicelli, L., Cooper, T., & Fisher, T. (2015). "The role of values in collaborative consumption: insights from a product-service system for lending and borrowing in the UK"(PDF). *Journal of Cleaner Production*. 97: 21–29. doi:10.1016/j.jclepro.2014.07.032 – via doi:10.1016/j.jclepro.2014.07.032.

enable collaborative and flexible consumption[23]. A subset of the researched companies has reflected such forward-thinking design strategy to meet growing customisation demands.

As such, there are four design theories that industrial designers and manufacturers should be aware of: Product Family Architect, Product As Platform, Product as Service and Flexible Manufacturing.

6.3.1 Product Family Architect Approach

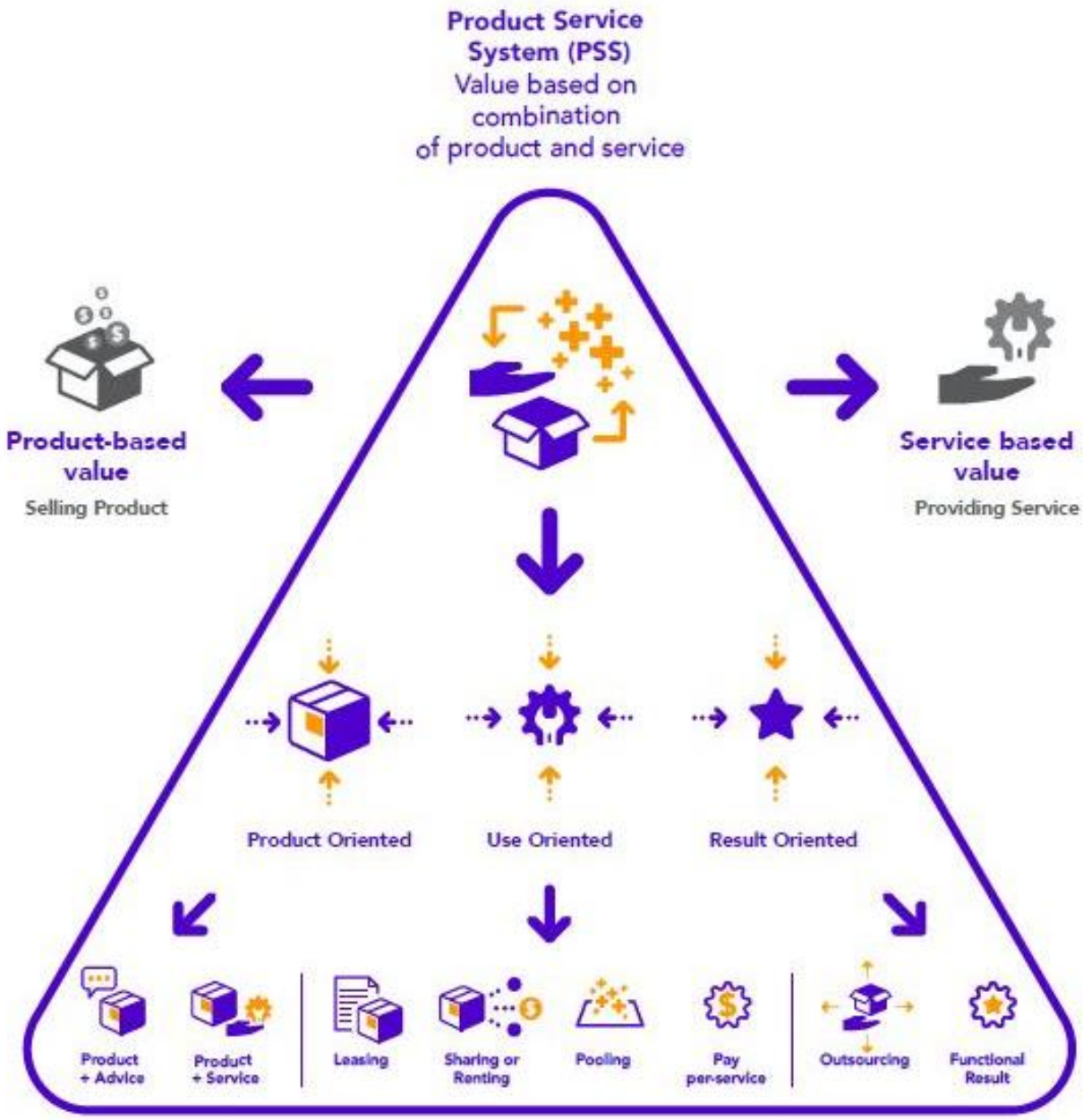
Product-family-engineering, is a software engineering method to create subsets of architecture under an organisation's product platform, with the design considerations of both commonalities and variances. By focusing on developing new products through maximising existing product family components and structures, the design strategy is no longer isolated to just one product design anymore. Instead the consideration must be inclusive to cover a wide range of combinations and modularities for the manufacturer to produce and assemble. According to Carnegie Mellon[24], this approach applied in product development can lead to higher productivity, higher quality, faster time-to-market, and lower labour needs.

Yick Shun Group, a toy manufacturer, has demonstrated the concept of product-family approach across some of their product lines. For example, the wheels and chassis are mostly standardised for mass production, separated customisable parts such as the exterior and decors to be produced in batches for various toy cars series. By leveraging existing parts to new designs, Yick Shun Group was able to maximise their variety of products while mitigating on costs of productions and engineering.

[23] Deloitte. (n.d.). Flexible consumption business models. Retrieved from https://www2.deloitte.com/us/en/pages/technology-media-and-telecommunications/articles/flexible-consumption-business-models.html

[24] Carnegie Mellon Software Engineering Institute (SEI). Software Product Lines. Retrieved February 17, 2006, from: http://www.sei.cmu.edu/productlines/.

Figure 26
An illustration on Product-Service-System (PSS) processes



6.3.2 Product as Platform Design

Product-as-Platform, is one concept which expands the value and product lifespan. With platform centered as design, the product itself can have endless modular features and add-ons because of enabling technologies. In technological terms, platform often refers to software-based system. In design, platform is an extension of intangible values to the tangible forms. This concept can be examined through the global success of iOS and Android platforms. With cellular phones are tangible interfaces, the mobile application platform enables greater reach and scale in customisation and personalisation. Simply put, the success of these platforms leverage growth model based on scaling the base modules. Platform can also take forms in governance models, where policies and

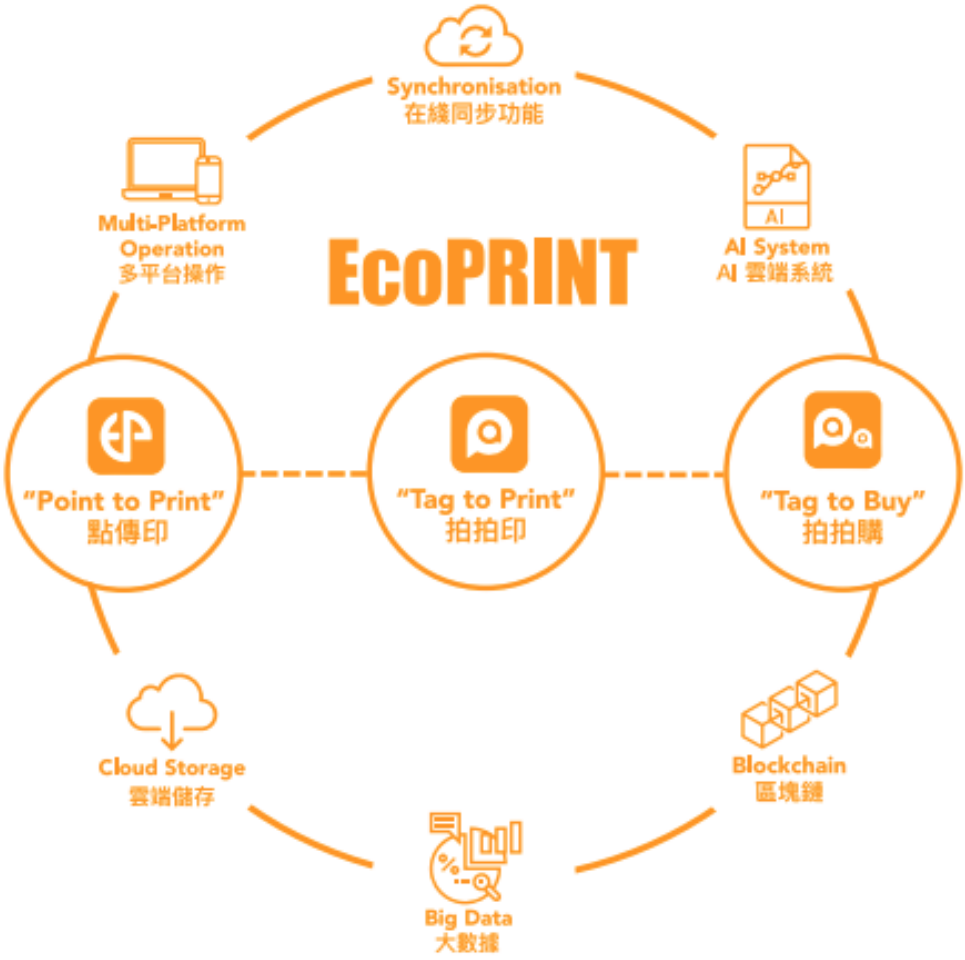
standards are enforced to reduce cost of innovation in technologies. Other platform services take open form, where users can participate, collaborate and cocreate to extend the platform's functionality. The collective pool of knowledge from mass user engagement further enrich the platform capacities to the products itself.

In Hong Kong, ECOprint as a technology company has launched a cloud-based platform, specialised in AI data storage, blockchain encryption and analytics. By overlaying a digital platform on top of physical printing infrastructures, the centralised platform allow vendors to customise printing services and packages, ultimately benefiting end consumers who are sourcing printing services. Another example is Grandion / TML, a mass garment manufacturer, which developed self-serve kiosk systems for consumers to upload their own images, via their online platform, to be customised and printed on selected clothing. The finished product will be mailed shipped to consumers within several days, making the purchase experience more seamless and desirable.

About ECOprint

EcoPRINT is a technology company of printing and cloud intelligence, specialising in the core technologies of AI cloud storage, cloud computing, blockchain and big data. It offers a centralised platform to customise printing services and packages, adding value to the printing industry by leveraging Industry 4.0 technologies and providing cloud intelligence solutions.

Figure 27
The centralised cloud-based platform of EcoPRINT offers one-stop and customised printing solutions and packages



About Grandion Group

The Grandion Group was established in 1996, which has developed from a casual wear manufacturer to an integrated casual wear supply chain enterprise with production facilities in the mainland. In 2015, the Group established the TML Tower in Tsuen Wan, creating the new industrial initiative “TML (To Make Locally)”, a one-stop smart manufacturing base that combines collaboration, production, technology and sales. Through support on supply chain, fundraising, training and sales channels, it offers full business support to young and emerging Hong Kong design talents for design commoditisation and entrepreneurship. For example, by introducing new printing technology and rapid replenishment system, low-volume, high-quality fast fashion apparel can be produced with reduced market risks and inventory costs, providing the customers with customised production services.

6.3.3 Product as Service Approach

Opportunities to redefine physical products to be service driven are also growing. Product-as-Service are made possible due to digitalisation. The concept of Product-Service system originated as function-oriented business model, with the aim to sustain both consumption and production[25]. With digital services and physical products intersecting across multiple platforms, digital offerings create new magnitudes of values and unbound physical limitations.

Share economy, a concept that emerged in recent years, leveraging collaborative consumption on underutilised goods and services, and shifted the focus from ownership to access. Global companies like Uber (shared vehicles) and AirBnB (shared housing) have created great successes leveraging this concept. In reference, a notable example is an automobile tire manufacturer, who introduced the “Tire by miles” programme, redefined tires as consumer products into utility service model. Instead of purchase, consumers pay for the mileage or distance travelled on the tires - shifting the fixed costs to variable costs in alignment to usage.

There are several benefits to this strategic approach. Firstly, consumers can access all sorts of products and services temporarily without the liability in ownership. This enables the market to try and experiment with various experiences and still retain the option to purchase when necessary. Secondly, consumers feel that they have more choices on product usage as service utilisation has higher degree of flexibility. Thirdly, manufacturers and designers can obtain real feedback and data from consumers’ usage, increasing satisfaction and accuracy of both product and service deliveries. Product-as-service approach is not simply designing better products, rather the notion requires fundamental change on how to fulfil consumers’ needs than just transactional relationships. This change yields higher value creation, and the success of product-as-service model should be strategically examined to benefit manufacturing design and development.

6.3.4 Flexible Production Environment

With different design to manufacturing and business models, industrial production systems also changed. Customisable yet can be mass produced products require flexible systems and machines conditions to be met. Machines and systems need to be more adaptable to retrofits and upgrades,

[25] Nicola Morelli, Ph.D. Industrial Design and associate professor, Institute of Architecture & Design, Aalborg University, Denmark.

yielding in higher versatility in production variations without jeopardising time and costs in the manufacturing line.
Industrial flexible manufacturing systems, also known as FMS, are higher degree manufacturing systems with flexibility to simultaneously produce variety of part types[26]. FMS is comprised of autonomous robots, computer-controlled machines, computer numerical controlled machines (CNC), and more. With machine flexibility, a diverse range of parts can be manufactured with minimal requirements in switching tools on the machine. Without losing production time, technological progression has allowed sophisticated manufacturing procedures to be attained while parts can be machined separately instead in batches and in masses.

Additionally, routing flexibility enables systems to prepare for breakdowns and unpredicted situations without interruption to parts production. Each machine ability is no longer singular and can be synchronised simultaneously with all other machines, resulting in all nodes of workstation to be able to perform the distributed activities, and parts can be produced via different routes under unpredicted situations. The overall flexibility in this manufacturing design is achieved with machines connectivity and versatilities, acting as network nodes instead as traditional bus network[27]. Furthermore, the flexible system architectural layout is intended to achieve multipurpose handling and processing, resulting in control to adapt to fluctuations of volumes in production.

Upon our interviews with Hong Kong manufacturers, under 15% has indicated their manufacturing capabilities have advanced to higher automation and flexibilities, and over 43% stated the interests to modify and upgrade their systems and machines in the next 3 to 5 years. The significance of change may not reflect in the current statistics from our research sample pool of designers and manufacturers. However, with the high interests and potential in shifting production methods, the transformation will be crucial to prepare for the upcoming years.

Values in production	
Machine flexibility	Product types Process variance Degrees of operations
Routing flexibility	Volume and batch variance Expansion

In the past, small batch production was not feasible in cost effectiveness compare to mass production. However, distributed manufacturing through multiple small-scale manufacturing bodies, integrated through platform systems for synchronised communications and data consistencies, allow lean yet agile manufacturing on par to large volume productions.

[26] Stecke, Kathryn E. (March 1983). “Formulation and Solution of Nonlinear Integer Production Planning Problems for Flexible Manufacturing Systems,” *Management Science*. 29:3, p. 273-288.
[27] Stecke, Kathryn E. and Solberg, James J. (Jan 1982) “The Optimality of Unbalanced Workloads and Machine Group Sizes for Flexible Manufacturing Systems,” Working Paper No. 290, Division of Research, Graduate School of Business Administration, The University of Michigan, Ann Arbor, MI.

7. Insights and Recommendations

7.1 Outcomes of Scale Customisation Thematic Workshops

AT A GLANCE

THREE THEMATIC WORKSHOPS

- 3 thematic topics: IoT, Big Data and Product-Service-System model as thematic discussion for innovation breakthrough
- Design tools: personas, problem framing, technology trend shifts, concept link, challenge questions, stakeholder map
- Ethnographic observation and action research on participant knowledge to content engagement

INTERACTIVE INSTALLATION AT THE EXHIBITION

- Inspired by “WHAT MADE ME”, by Dorota Grabkowska, Birmingham, UK
- 66 elements related to design and manufacturing
- 400 visitors participate on contributing the answers for the questions “what you value”, “what you do”, “what you want”, and “what you change”.

DATA ANALYSIS & CONCLUSION

Comparative analysis:

- Affinity clustering - differences and similarities
- Insight finding: discover patterns and characteristics
- Evidence finding
- insights on challenges, recommendations and opportunities

With the inherent multiple facets of product-service systems (PSS), Internet of Things (IoT) and Big Data, the traditional offering to design and evaluate product, service or system per se is no longer enough to meet the increasingly sophisticated market. The challenge is magnified when customisation is required within the new manufacturing revolution of Industry 4.0. A paradigm shift has been set in place to combine product, service and system all into one for added value. Hosted in summer 2018, Hong Kong manufacturers and designers from all areas of disciplines were put together in a series of innovation workshops, where new business models integrated new industrial technologies were created through design thinking process.

During the Thematic Workshops, participants were able to experience the design thinking method, starting with development of empathy using broad-based personas. The personas were carefully researched and designed to mimic new generation consumer behaviours and living environments, allowing each participating team to understand and relate to the market which the team must serve. Multiple design challenges to customisation needs are then added to the design process. Next, the nine pillars of Industry 4.0 technologies were incorporated into the manufacturing value chain, allowing participants in the design workshop to perceive and make sense of product design process in the new ecology. For the comprehensive workshop tool kit, please refer to Appendix B.

Each team, according to their respective problems and products, utilised various design thinking tools to enrich their creative discussions and findings, resulting in innovative service and product models. Three future business ideas, incorporating scale customisation strategy with Industry 4.0 technologies, were selected and showcased in this book on the plausible future.

Sharing Sessions by Expert Speakers
專家講者分享環節

Mutualism Design: Industry 4.0 and Beyond
共生設計：工業 4.0 及後

Beast Jiang 姜曉陽 | CN 中國

Deputy General Manager & Creative Director, Artop Design Group Co., Ltd.
雅奕設計集團有限公司 常務副總裁創意總監

Managing the Coming Disruption from Industrial IoT
管理工業物聯網迫在眉睫的沖擊

Richard Mark Soley | US 美國

Chairman & CEO,
Object Management Group
Executive Director,
Industrial Internet Consortium
對像管理組織 (OMG) 主席兼首席執行官
工業網際網絡聯盟 (IIC) 行政總監

Customisation: Scaling Your Business the Smart Way
客制化：智能技術助你擴大業務

Ugo Negretto | DE 德國

Managing Director, ENICMA GmbH
ENICMA GmbH 執行董事

7.1.1 Workshop Concept #1

Airlines and travellers can now enjoy painless luggage check-in and travels.

Intro

For a consumer, luggage is simply a container to hold traveller's items. However, almost everyone had encountered various issues with our luggage when travelling. Whether it's lost in transit, or queued in long waiting lines for baggage drop-off, or overweight items making us scramble in the airport to repackage our luggage, there are alot of user challenges. From M2S workshop, our participants analysed the challenges and come up with a conceptual, customisable and adaptive solution with I4.0 manufacturing. The product itself has evolved to become an integrative product and service offering, transforming the user experience with the luggage throughout the travelling engagement point.

Experience Flow

1. Pack your luggage and prepare to travel at ease. The intelligent luggage has modular compartments, weight sensor calculations, alert system and temperature sensor
2. Through cloud secure gateway connected to multiple airlines' database, you can now check-in your flight and luggage virtually. A unique digital ID (replacing paper scanning) will then be sent and displayed on the digital screen on your luggage
3. No more lineups and wait time at the airport. The automated kiosk can scan your luggage digital ID through synchronised cloud data
4. Worry free while travelling. With GPS location and the secure ID, you can track your luggage anywhere you go and feel safe
5. The intelligent interface will notify your mobile phone within proximity during airport baggage pickup. Making it hassle-free to wait and search for your luggage

Figure 28
The collaborative luggage ideas developed by one group of participants during the 3-hour Thematic Workshop 1 on New Business Models of Product-Service-System

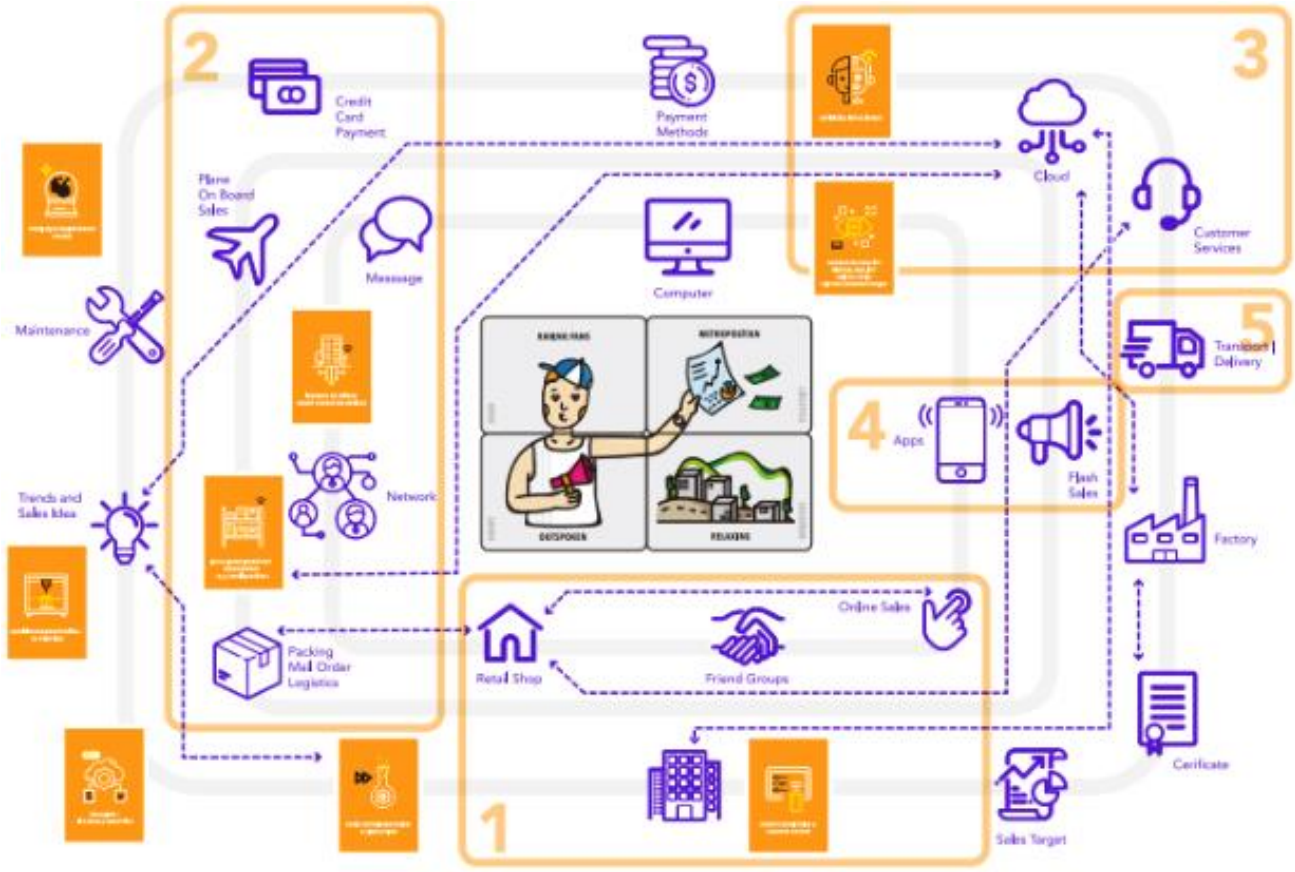


Figure 29
Facilitator Frederico Li explained to participants on the use of innovative tools for company breakthrough during Thematic Workshop 1 on New Business Models of Product-Service-System on 30 June 2018 at PolyU ThinkTank

7.1.2 Workshop Concept #2

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Premium custom man suits to meet working professional needs upon travel

Intro

Busy working professionals, who travel for short business trips, frequently need to suits for formal meetings and events. The main problem is that carrying multiple suits for mixtures of occasions is impossible and inconvenient. From M2S workshop, our participants analysed the challenges and redesigned a service model to custom tailored suits.

Experience Flow

1. VR / AR platform for customer to visualise suits' style and cutting, with customised measurements to enhance shopping experience
2. Through a membership-based online portal, all customers will have their own virtual closet. Customer can craft as many choices of suits as needed for various occasions
3. During travel, customer can easily select their style needs using their virtual closet. Parcel will be shipped out to airport VIP lounge - acting as point of sales and delivery
   Upon flight departure, customer simply leaves the suits at the VIP concierge. Airport service will return the suits to the company
4. The suits are 3D printed by parts and can be disassembled and reprocessed for future use

Figure 30
The collaborative suits customization and delivery ideas at the airport developed by one group of participants during the 3-hour Thematic Workshop 2 on Internet of Things (IoT) / People (IoP)

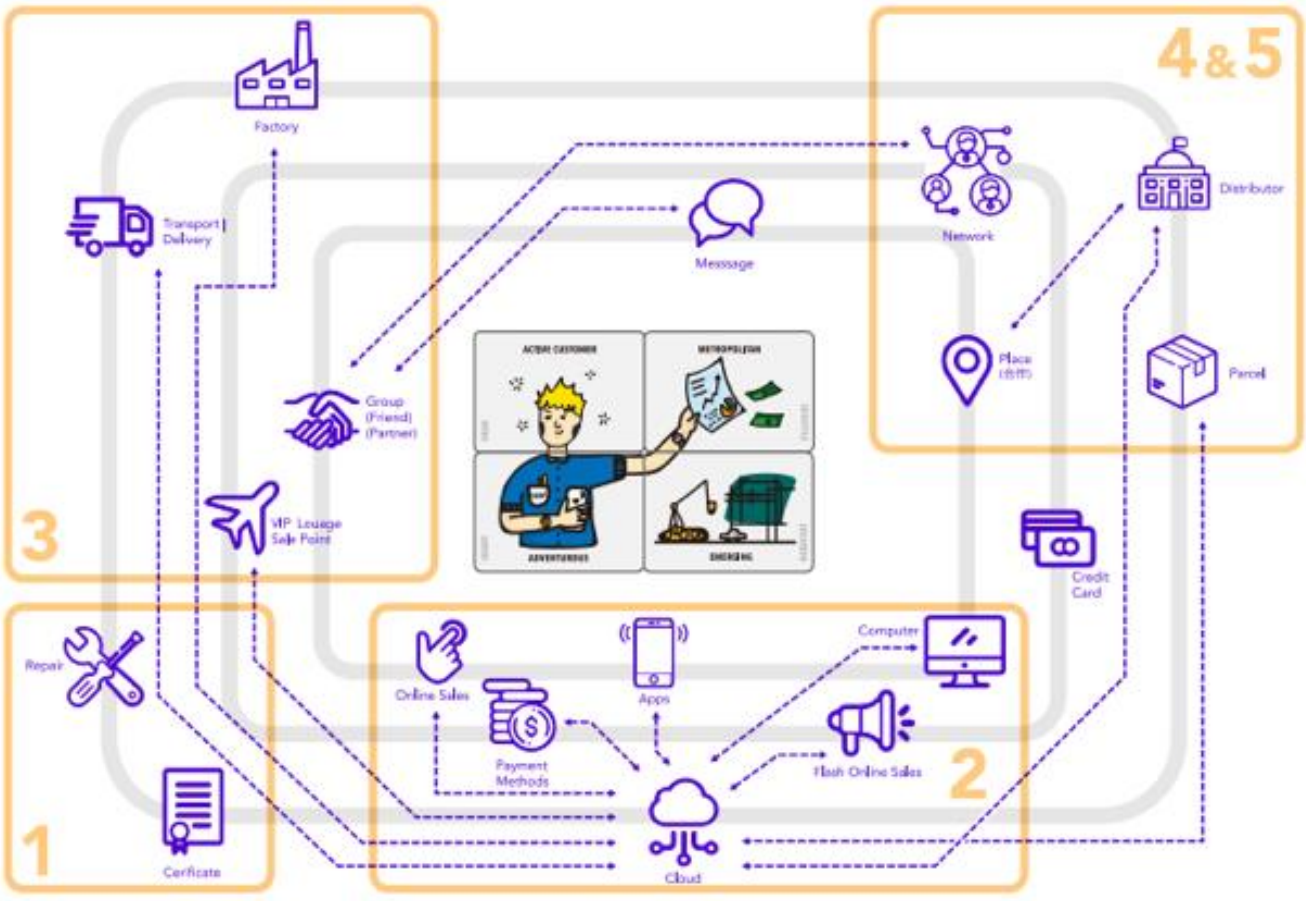


Figure 31
Facilitator Kent Wong guided participants towards employing innovative tools for company breakthrough during Thematic Workshop 2 on Internet of Things (IoT) / People (IoP) on 30 June 2018 at PolyU ThinkTank

7.1.3 Workshop Concept #3

Home users can store and preserve fresh food in any ways they like in the future.

Intro

Every family use the fridge as storage for fresh food, and it has become a ubiquitous feature of the home. Interestingly, there are limited flexibility in which one family can personalise the compartments and controls for more specific usage and needs.

The M2S thematic workshop participants developed a deconstructed modular fridge - “LEGO” style, with each compartment physically interchangeable, and digitally connected via network as independent modules. The concept incorporated scale customisation strategy with several I4.0 technologies.

Experience Flow

1. Every fridge contains standalone compartments, with remote controllable sensors and temperature control
2. Inspired by Google Project Ara, the fridge can be freely assembled in irregular or regular upright structure in accordance to available home usage space
3. The fridge has an intelligent system that can scan and detect the types of fresh food in the compartments. Connected via digital platform between consumers and food retailers, users can easily replenish fresh food stockings through this smart monitor and order system
4. Further usage of the smart scanning system enables user to detect rotting food, ensuring all food in the fridge is kept fresh all the time
5. The types of food are detected through sensors and integrated via cloud to internet. Food recipes will be recommended via the digital platform to the user on their corresponding food in the fridge

Figure 32
The collaborative smart fridge ideas developed by one group of participants during the 3-hour Thematic Workshop 3 on Big Data Analysis

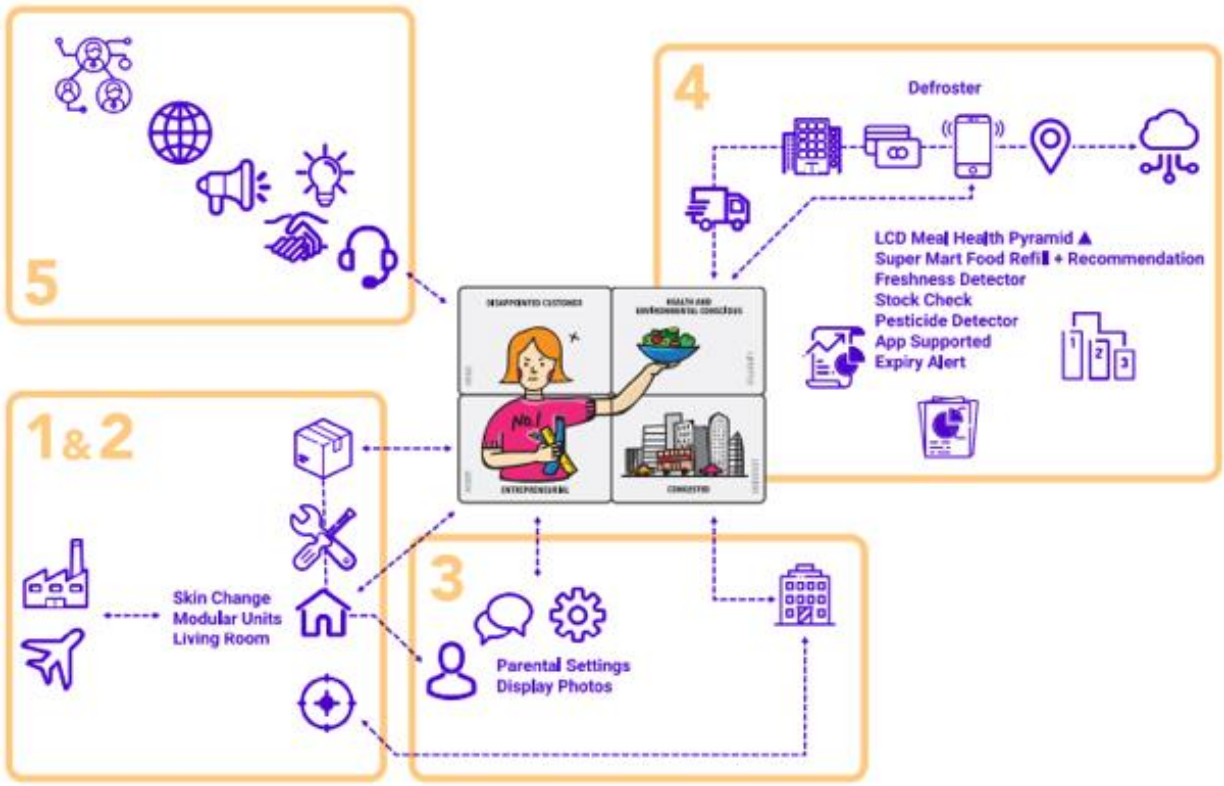


Figure 33
Facilitator Freddy Law exchanged with participants through the innovative tools for company upgrade and transformation during Thematic Workshop 3 on Big Data Analysis on 30 June 2018 at PolyU ThinkTank

7.2 Interactive Installation: What makes Design and Manufacturing?

A word map comprised of elements of design and manufacturing terms, extracted from researches and findings.

It is a participatory design* to understand designers and manufacturers, who attended the DesignInspire exhibition, areas of interests, values, actions and thinking in their respective organisations.

On one side of the board, the words are visualised in a structured but randomised order. On the side, there are four different colors associated to four questions:

- What you value
- What you do
- What you want
- What you change

Participants can explore freely and connect words that best represent and resonate with them through the questions.

After three days through the exhibition, the end result was collected and analysed.

*The art installation is inspired by “WHAT MADE ME” - Dorota Grabkowska, Birmingham, UK

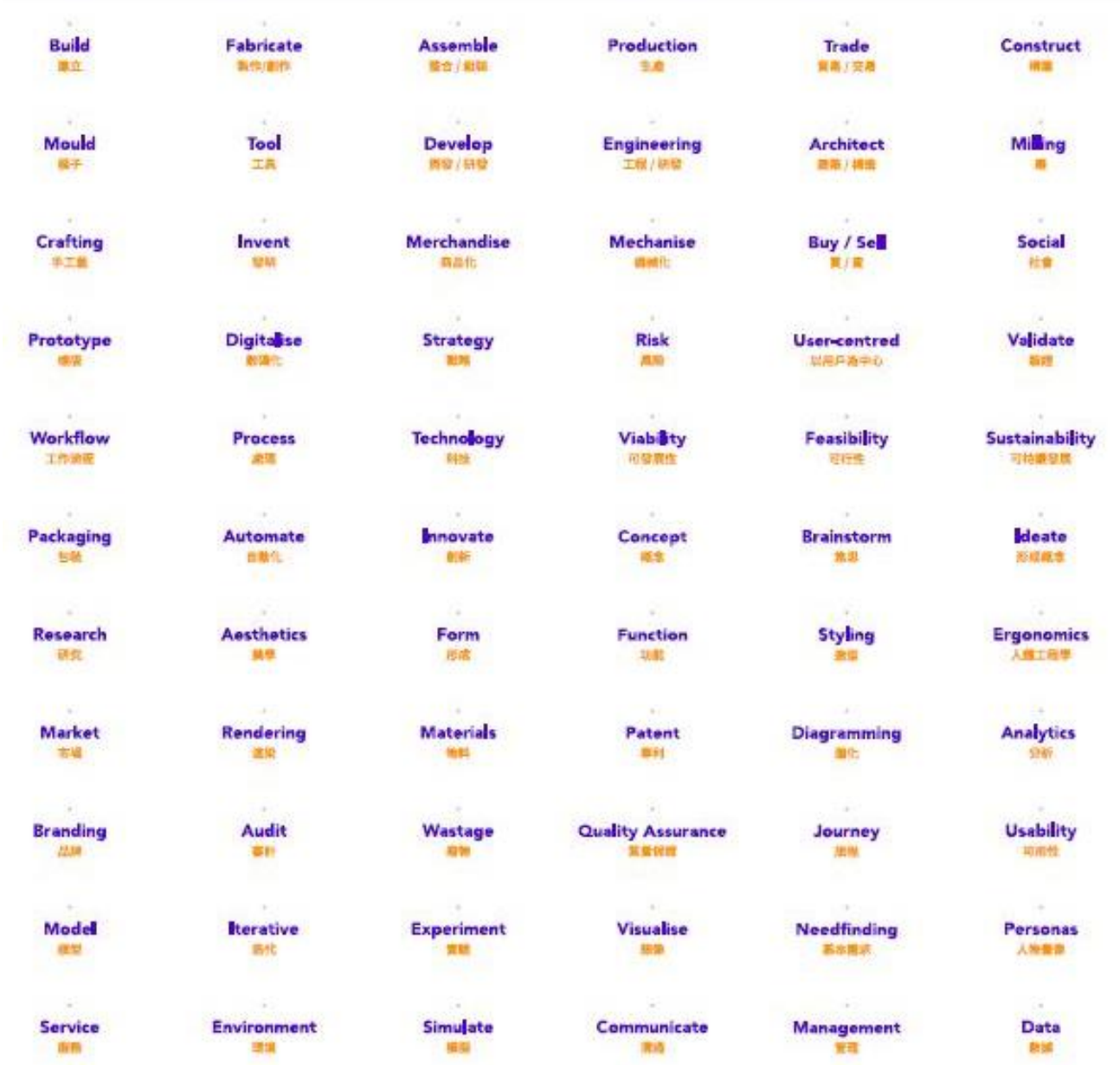
Figure 34
Interactive installation comprised of elements of design and manufacturing terms, inspired by “WHAT MADE ME” - Dorota Grabkowska, Birmingham, UK

400 visitors participated to contribute answers to the 4 questions: “what you value”, “what you do”, “what you want”, and “what you change”.

66 words of 180 were selected and generalised from the research content, including interview transcripts, published articles, reports and academic research papers. The purpose of adopting this interactive design is to create a participatory experience to understand resonance of designers and manufacturers. Through the DesignInspire exhibition, we can further study public engagements and their respective areas of interests, values, actions and thinking towards industrial development.

Each color string has its own representation and users can explore freely and connect words which best represent and resonate with them through the questions.

Figure 35
66 elements related to design and manufacturing



● Value	Aesthetics, Branding, Concept, Environment, Form, Function, Journey, Packaging, Patent, Personas, Styling, User-centred, Social, Sustainability, Usability
● Do	Architect, Assemble, Audit, Buy / Sell, Construct, Diagramming, Engineering, Ergonomics, Iterative, Rendering, Management, Milling, Model, Production, Prototype, Tool, Trade, Workflow
● Want	Analytics, Automate, Data, Digitalise, Feasibility, Market, Materials, Mechanise, Merchandise, Process, Quality Assurance, Service, Strategy, Technology, Validate, Viability
● Change	Brainstorm, Build, Communicate, Crafting, Develop, Experiment, Fabricate, Ideate, Innovate, Invent, Mould, Needfinding, Research, Risk, Simulate, Visualise, Wastage

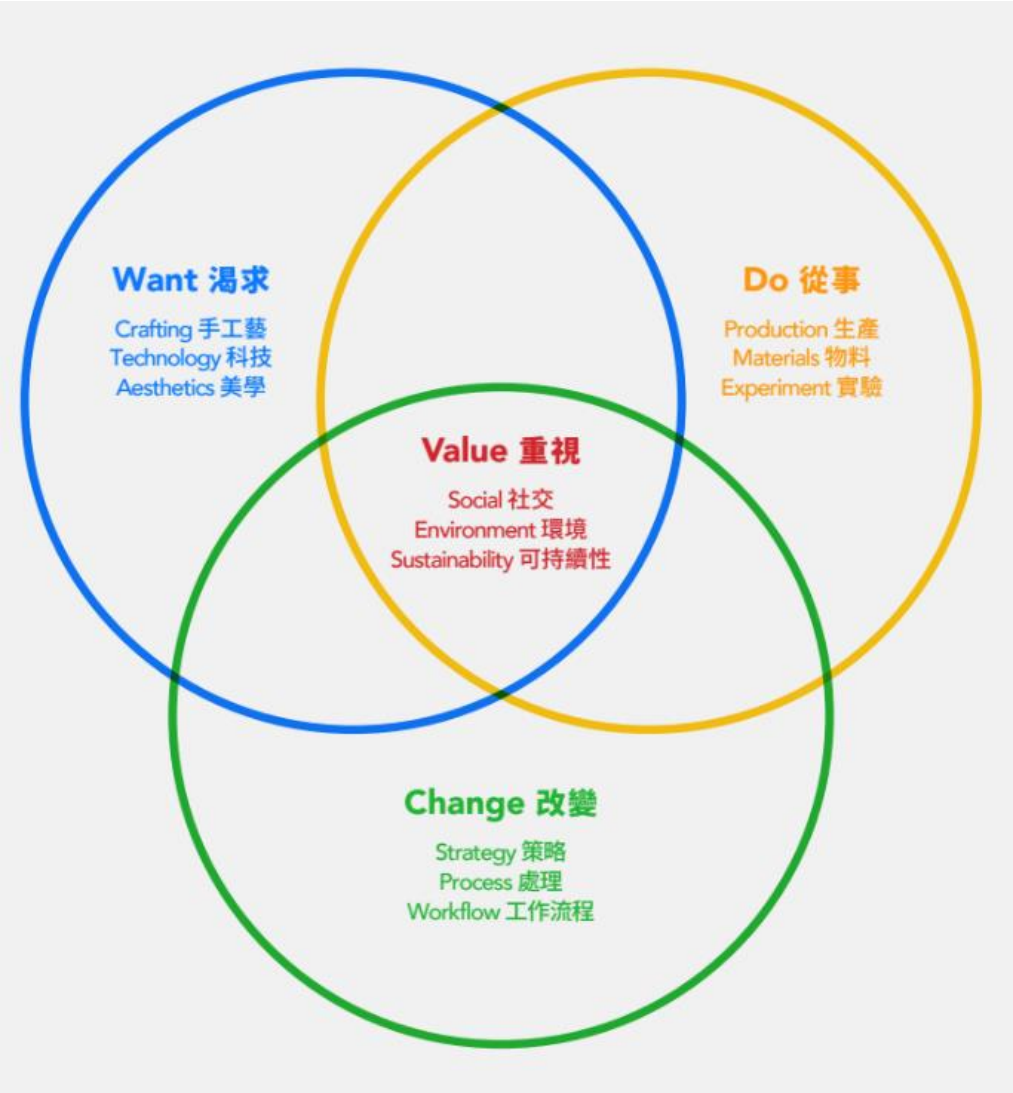
The Outcome

A total of 400 strings were prepared and approximately 95% were consumed (through tally) in 3 days. For each color, the most engaged words are identified for further analysis.

● Value	Iteractive, Environment, Concept, Social, Sustainability, Viability
● Do	Production, Materials, Experiment
● Want	Aesthetics, Technology, Crafting, Visualise
● Change	Strategy, Process, Workflow, Build

The findings allowed us to preliminary understand that participants' collective values (red strings) towards design are reflected by words like social, environment and sustainability. Actions (yellow strings) are activities which designers and manufacturers conduct, and words like production and materials indicate majority of operating activities in design and manufacturing. Experiment was another key word which revealed in this interaction, leading one to ponder the importance of experimentation in designs. The blue strings reflect consumers' desires to technology and aesthetics. Strategies, processes, and workflows are areas in which participants changed the most.

Figure 36
The interpretation of outcome being mapped into the design innovation Venn diagram



The desirable outcomes in design and manufacturing are driven through three spectrums: changes in progressive strategies and iterative processes, supported by technological systems in production designs, and the willingness (mindset to actions) to prototype and experiment. The intersection of all three (change, want, do) yields a collective representation of current Hong Kong market expectations towards the industrial space: A social driven future which is environmentally sustainable.

7.3 Recommendations

Hong Kong Industrial Design Professionals (HKIDP)

Hong Kong Industrial Design Professionals (HKIDP) are encouraged to look beyond the physical artefacts to dive into the waters of digital experience for the consumers and product diversificaition. In the process of building a digital system of operation, it is also essential for HKIDP to adopt system thinking and consider a product design in ways that easily fits into the operation. With a fully digitalised operation system along the supply chain, valuable data will be generated, to which

HKIDP should recognise its significance and make full use of it to further system efficiency and product enhancement.

Manufacturers

In terms of hardware, manufacturers are advised to seriously look into hiring a team of technologists at professional level to adapt the necessary technology for development. Though the primary role and specialisation of manufacturers is manufacturing, the acquirement of diversified knowledge outside of manufacturing for a better understanding on the consumers' needs always adds value to the business. Collaborative customisation among manufacturers in different scales has also led to great success, where different expertise and resources are pooled for innovative product-service-system.

8. Conclusion

Future and Opportunities

Mass production and scale customisation satisfy different markets, the former being mass consumers and the latter niche segments. Yet, the mass markets are progressively becoming more segregated and diverse, in turn niche markets will prevail. The transformation to adopting scale customisation in Industry 4.0 as manufacturing strategy becomes inevitable.

Traditional production supply chain is linear, creating a sequential value flow and delivery pipeline from producers to consumers. However, the linear model is historic in the era of scale customisation in Industry 4.0. Enabling technologies virtualise and decentralise the traditional model, transforming the supply chain into an "Integrated supply network" (a meshed network). The increase of connectivities further leveraged on the transparency of consumer behaviours and interactions, thus empowering manufacturers with most up-to-date insights to be proactive to market changes on demand. Manufacturers can now flexibly produce with specific market preferences and volumes, with higher efficiencies in inventory management and synchronised coordination with all stakeholders across the supply network. Physical and Digital spaces are now intertwined. The aggregation of information reconstructs the logic in which people and businesses operate, in a completely connected and unified network (instead of a chain).

It will be an uptake in technologies, and this journey requires forward thinking, a growth mindset which can maximise the best value creation. For designers, artefacts and products are only interfaces and vehicles in which users engage with, and only those that capture users' needs accurately and quickly will excel in the competitive business world. Globally, the open flow of information and innovation through technologies has augmented huge impacts on the growing economies of scale, ultimately benefiting ways in which consumers access knowledge, products and services. As society further into creating shared values, the positive influence overwrites the traditional zero-sum thinking. Industry 4.0 is beyond upgrading technological infrastructures, it is a new paradigm in which all stakeholders across the industrial landscape work collectively and synergistically to increase mutual benefits.

Appendix

Appendix A - List of Interview Questions

Objective: The interview is structured to draw implicit insights and reflection from the interviewee on their knowledge capacities (from various perspectives) towards Industry 4.0, followed by revealing the relationship between the business strategic development, consumer expectation, and technological enhancement in manufacturing production processes.

1. What is 'Scale [Mass] Customisation of Industry 4.0', and how do you think this has impacted your business in reshaping the organisation strategies and operations?

2. How do you interpret the differences of customisation (traditional approach) and scale [mass] customisation (new approach) of industry 4.0?

3. Could you please share in your opinion, in a high-level view, progression with scale [mass] customisation of industry 4.0 in Asia / (HK if applicable) Hong Kong? In other words, what do you think about the interrelationship between the competitive advantage and its main drivers? If any, what are the main drivers?

4. How do you see the new roles of industrial design professionals, manufacturers, and retailer OR all in the scale [mass] customisation of industry 4.0?

5. What challenges do you see them (industrial design professionals, manufacturers and retailer, supply chains) need to overcome to take advantage of scale [mass] customisation of industry 4.0 and further improve?

6. From new business model to new technologies, what are some key points SMEs, Retailers and Industrial Designers should be aware to thrive in this new economy?

7. With consumer expectations inclining heavily towards customisation of products and services, what suggestions and learning opportunities can you share for those stakeholders who is seeking change?

[Optional]

8. Does your business have any other branch office(s) / manufacturing base(s) outside of Hong Kong (especially in the ASEAN)? If yes, what is the geographical business strategy and why? If no, do you have any plans to extend the business geographically to ASEAN countries and why?

Personal Background

9. What is your background (design discipline; education background)?

10. What is your field of expertise now?

11. What is your position in the company?

12. What are your responsibilities in the company?

13. How long have you been working in this industry?

14. Have you received any training on any related design practices (methods, processes, strategies) and manufacturing practices?
    - If so, how did you apply this in your work?
    - If not, what other training have you received in which you find useful for work?

15. What types of changes and improvements, most noticeable/major/drastic, have you observed since (joining or leading) this business compared to now? (people, process, technology, etc)

Business Background

16. How long is your organisation history?

17. Which consumer market does your business target?
    - Can you name several successful product(s) / service(s) your organisation offers to consumers now? What made the offerings successful?

18. What drives the success of your business? Why?

19. How does your business create value for stakeholders [particularly consumers], including initial stages from sourcing, production, supply chain to sale of final product (stakeholders value chain)?

20. What are the innovations in your business and work now? How do you see these innovations help (or not helping)?

21. Can you share an unexpected situation, or most memorable experience, which influenced the [business strategy] or [manufacturing] process?
    - How was the situation addressed?
    - What drove these decisions?

22. If your client wants to have customisation product, how does your system respond?

Market Background

23. Can you share your views on current consumer behaviours / expectations and its influence to your business competitiveness now and future? What percentage of your market segment seeks customisable solutions?
    - [if applicable] What type of customisation and how does your business satisfy this need?
    - [if applicable] What challenges do you face with customisation?

24. From the 1st industrial revolution (mechanisation through water and steam power) to the mass production and assembly lines with electricity in the 2nd, then towards the 3rd with computers and automation. We are now at the 4th industrial revolution (Industry 4.0), furthering the industrial and manufacturing sector with smart and autonomous systems driven by data and machine learning (mass production → mass customisation).
    - How do you view this shift relate to manufacturing, retail and design sector?

25. What is your next 5-year view (future) of your business (if applicable, discuss more about production manufacturing) evolution?
    - What essential resources do you need to fulfil this? Can it start now; if not, what are the constraints?

Appendix B – Thematic Workshops Tool Kit

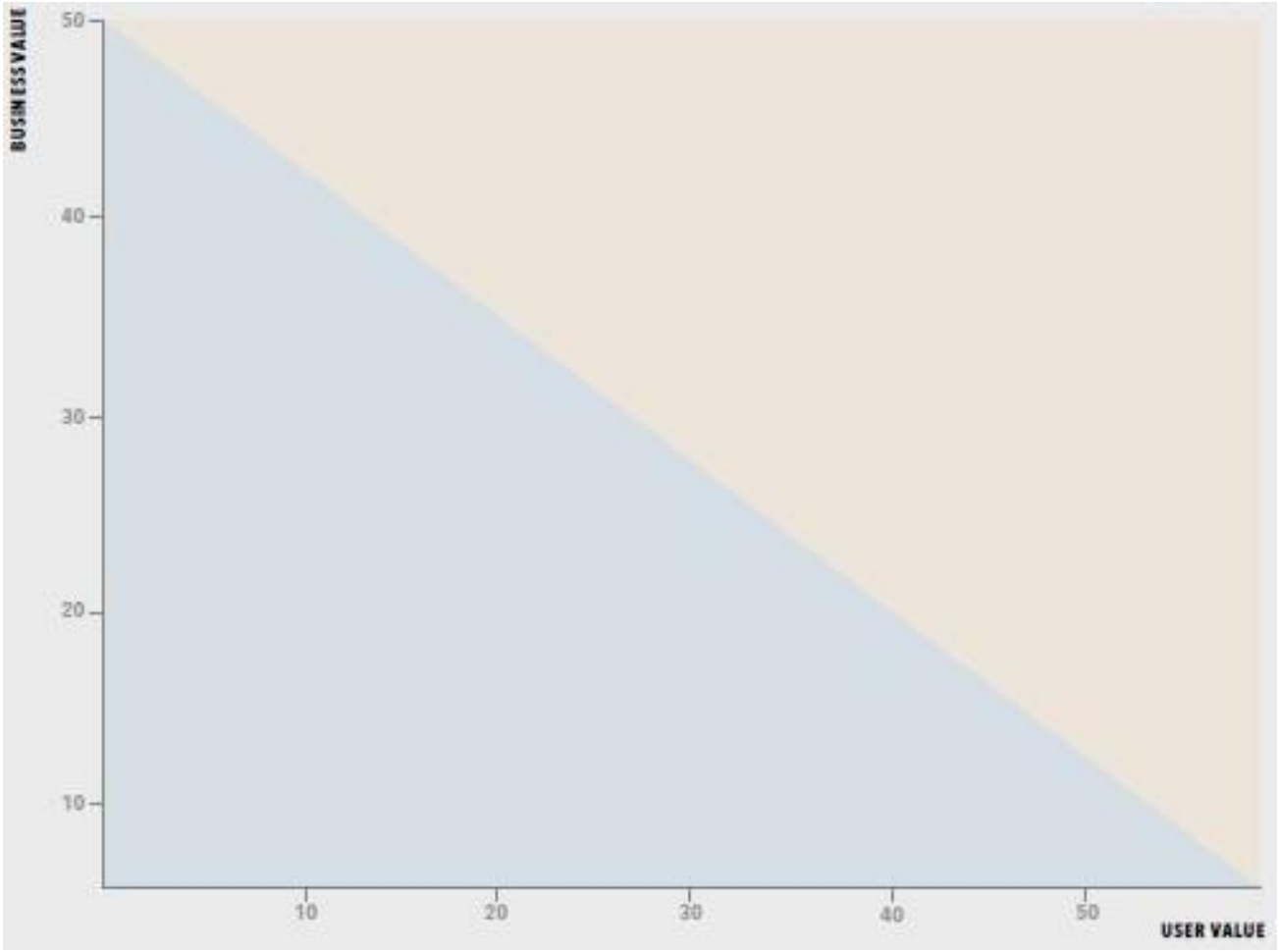
The Workshop Manual: An Overview

Shift Cards: Force-impose different hypothetical changes to the company

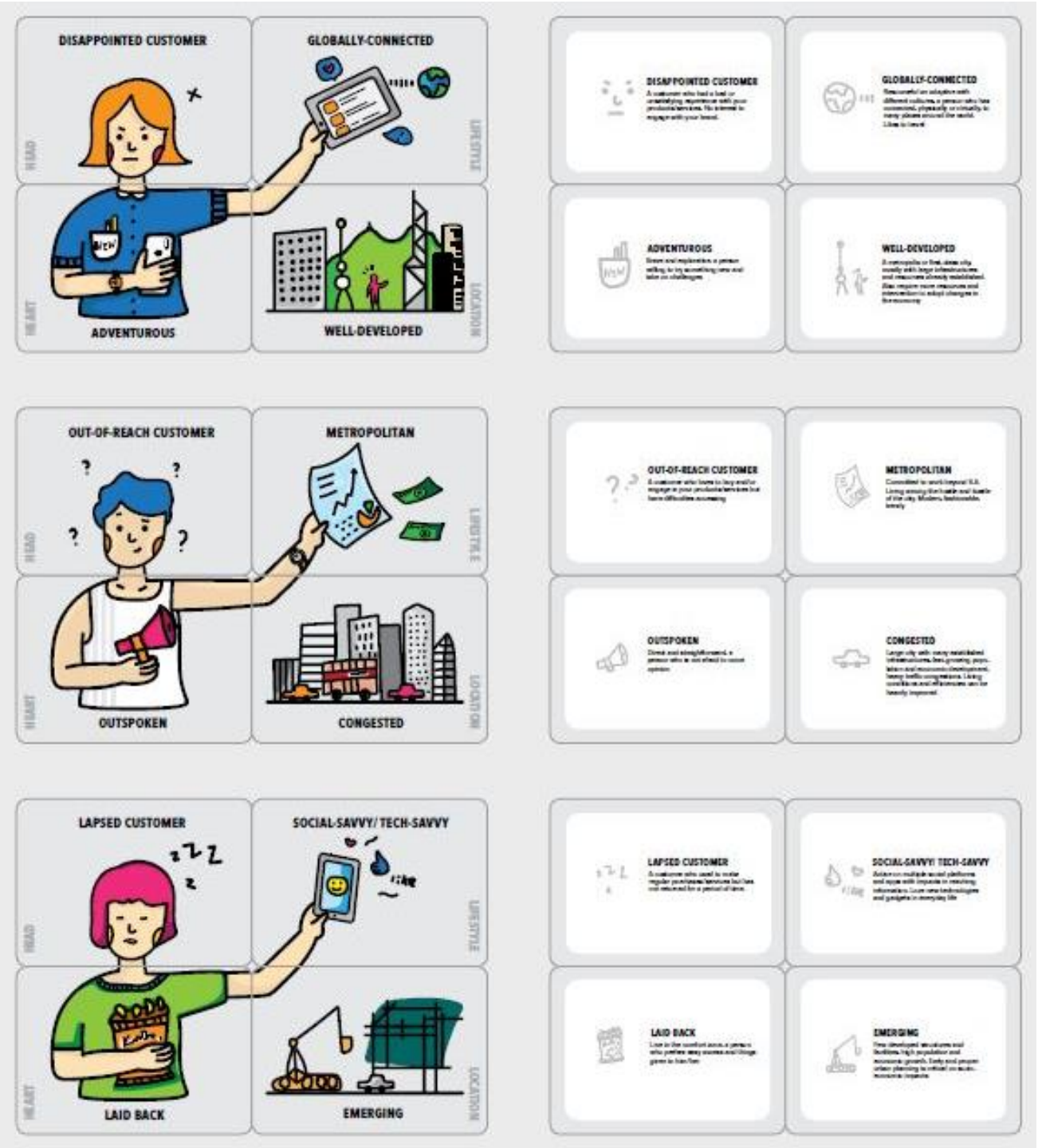
Shift Cards: Force-impose different hypothetical changes to the company

Shift Cards: Force-impose different hypothetical changes to the company

Concept Link Map



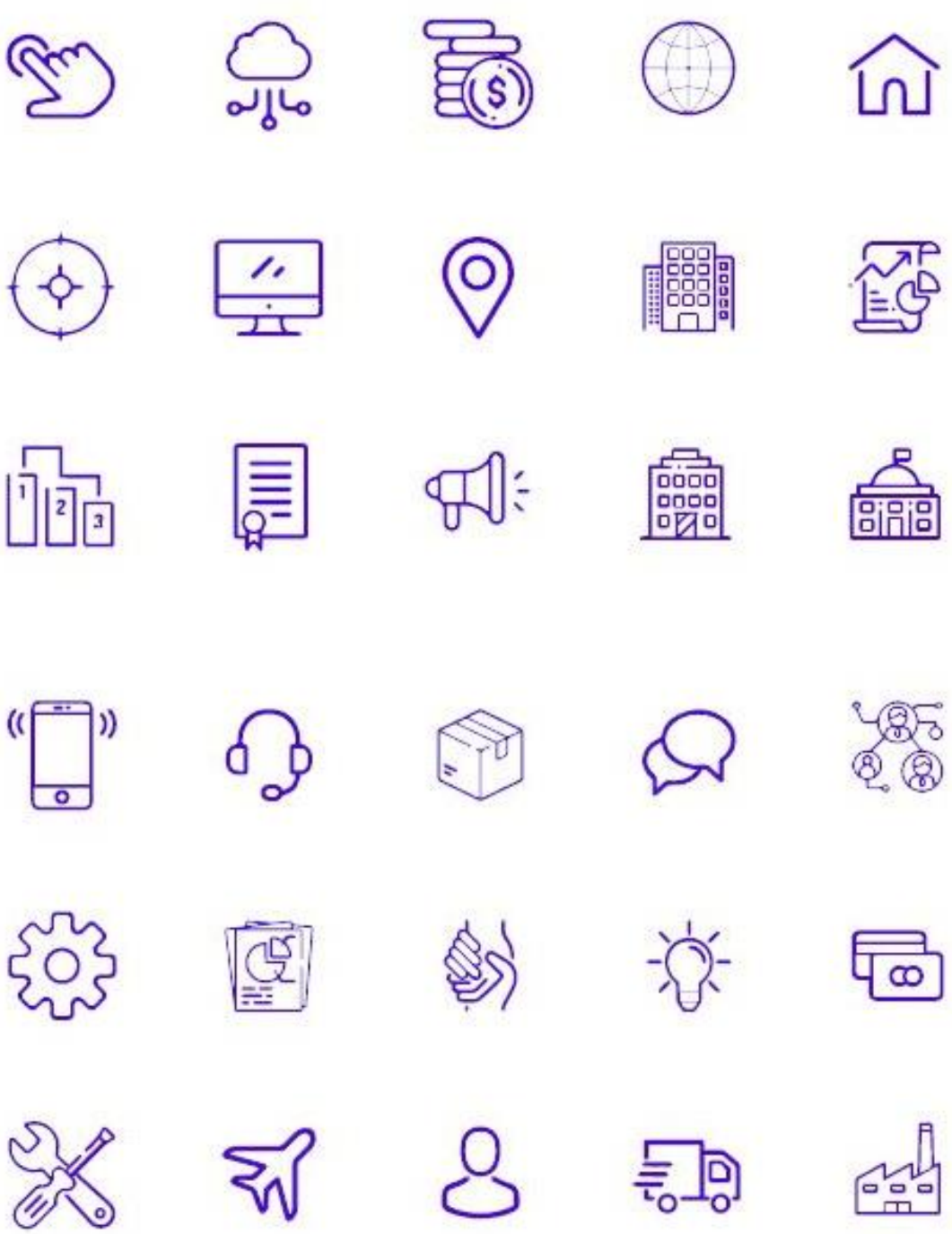
Persona Cards



Persona Cards

Customisation Cards: Add different customization options to both the company and the customers

Presentation Icons



Acknowledgements

Organiser

Collaborating Organisations

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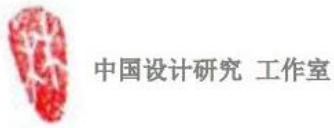
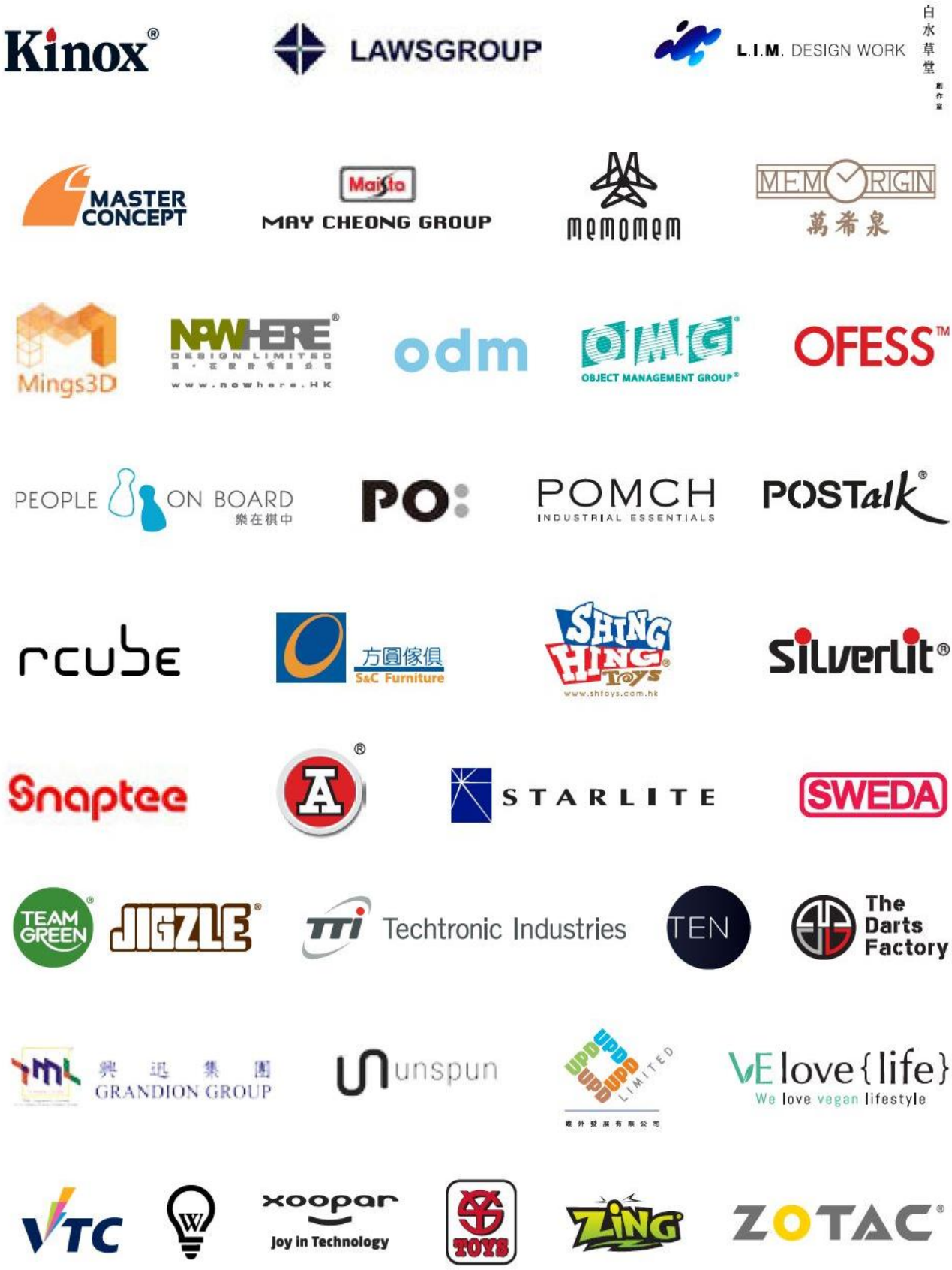
Any opinions, findings, conclusions or recommendations expressed in this material/any event organised under this project do not reflect the views of the Government of the Hong Kong Special Administrative Region or the Vetting Committee of the Professional Services Advancement Support Scheme.

List of Interviewed Companies



List of Interviewed Companies (Cont'd)



List of Interviewed Companies (Scale Customisation Suppliers)

I4	SC	ID	NI	Company Name (English)	Category / Discipline	Size of Company	Website
				9H	Furniture - Office	Big	
				Absolute Vintage Eyewear / Eyepopper	Eyewear	SME	https://absolute-vintage-eyewear.business.site/
				Airland Holding Company Limited	Houseware - Bedding	Big	https://www.airland.com/index.html
				Artop Design Group Company Limited	Houseware / Plastic Products / Metal Products	Big	http://www.artopcn.com/en/
				Asia Animation Limited	Toys - Animation	Big	http://www.asiaanimation.net/
				Association for Creative Education Company limited*	Design - Creative Industries	SME	http://www.creative.org.hk/index.html
				Best Victory Enterprise Limited* / KidoKare	Houseware / Plastic Products (works with IKEA)	SME	
				BigHorn / Winky International Limited	Eyewear	SME	https://bighornhk.com/zh-hant/
				China Design Research Work Group*	Industrial Design	SME	
				Cosso International Limited	Houseware - Kitchenware / Plastic Products / Metal Products	SME	http://www.cosso.com.hk/
				Dongguan Maisto Industries Limited (May Cheong Group)	Toys - Cars	SME	http://www.maycheonggroup.com/
				ECO Concepts	Fashion & Apparel / Houseware - Personal Acccesories	SME	www.ecoconcepts.com.hk
				ECOPrint Cloud Technology Limited	Paper Products - Printing Solutions	SME	https://www.ecoprint.tech/

				ENICMA GmbH	Production Efficiency	SME	http://www.enicma.de/en/index.htm
				Eone Bradley	Watch	SME	http://www.eone-time.hk
				Forever Couple	Metal Products - 3D-Printed Rings	SME	http://forevercouple.com/en/index
				Fraunhover Institute for Production Technology IPT	Production Technology	Big	https://www.ipt.fraunhofer.de/en.html
				Fullhouse World International Limited	Houseware	SME	https://www.fullhouseworld.com/
				Gear Atelier Limited	Industrial Design / Houseware	SME	http://www.tapas.com.hk/en/home
				Genic Eyewear	Eyewear	SME	https://www.geniceyewear.com/
				Gift Concept Product Limited	Houseware - Silicone	SME	http://www.giftconcept.com.hk/products
				Giormani / Arredamenti Company Limited	Furniture	Big	
				Goodway Electrical Enterprise Limited	Houseware - Electrical Appliances	Big	www.goodwayelectrical.com
				GOXD / Marvel Digital Limited	Houseware - Electrical Appliances	Big	https://www.marveldigital.com/
				Grand Classic Ltd.	Furniture	SME	http://www.grandclassic.com/e/default_home.asp
				Green & Associates*	Houseware - Environmental Products	SME	http://greenassociates.com/
				Greenology (a brand of UPD Limited)	Houseware - Decor (Concrete & Small Plants)	SME	https://greenology.com.hk/
				Ikonee International Limited	Plastic Products - Lifestyle	SME	http://www.ikonee.net/
				Inno Box Design Limited*	Toys (Manufacturer)	SME	http://www.innoboxdesign.com/

				InnoSphere Limited*	Houseware - Lifestyle & Baby Products	SME	https://www.innosphere.hk/
				Jervis SportsTechnology Limited	Sports - Basketballs	SME	http://www.jervissports.com
				Kentex Craft Limited*	Watch / Plastic Products	SME	http://www.kentexwatch.com/
				King's Flair Development Limited	Kitchenware - Supply Chain	Big	https://www.kingsflair.com.hk/
				Kinox Trading Limited	Houseware - Kitchenware / Metal Products	Big	http://www.kinox.com/
				LawsGroup	Fashion	Big	www.lawsgroup.com
				L.I.M. Design Work Limited	Industrial Design	SME	http://www.limdesignwork.com/ron
				Master Concept	IT - Cloud Computing	SME	https://www.hkmci.com/
				Memomem Limited*	Watch / Metal Products	SME	https://memomem.com/
				Memorigin Watch Company Limited	Watch / CNC Machining	SME	http://www.memorigin.com/
				Mings 3D Solutions Limited / Hong Kong 3D Printing Association	3D Printing	SME	http://www.mings3d.com/
				NowHere® Design Ltd.	Furniture - Interior	SME	https://nowhere.hk/
				Object Management Group (OMG)	IoT / Technology Standards Consortium	Big	https://www.omg.org/
				odm DJ (SZ) Limited*	Watch / Metal Products	Big	
				OFESS	Metal Products - Umbrellas	SME	https://ofessonline.myshopify.com/
				People on Board Social Enterprise Limited	Toys - Board Games	SME	https://www.pob.hk/zh/index.html
				PO Selected Company Limited	Houseware / Metal Products	SME	http://www.po-selected.com/

				POMCH	Fashion & Apparel	SME	https://www.pomch.com/
				POSTalk / Takon Product Development Limited	Paper Products	SME	https://www.postalk.com.hk/
				Rcube Design Studio Limited	Lifestyle Products	SME	http://www.rcube-design.com/product.html
				S&C Furniture Limited	Furniture	SME	http://www.sncfurniture.com.hk
				Shing Hing Plastic Manufacturing Limited	Plastic Products - Toys	SME	https://shtoys.com.hk/
				Silverlit Toys Manufactory Limited	Toys - Helicopters	Big	https://www.silverlit.com/a/
				Hong Kong Productivity Council - Smart Industry One Consortium	Productivity Council	HKPC	https://bit.ly/2MInbQt
				Snaptee Limited	Fashion	SME	https://snaptee.co/
				Star Industrial Company Limited (Red A)	Plastic Products	Big	https://www.starreda.com/
				Starlite Visual Communication Limited*	Paper Products	Big	http://www.hkstarlite.com/
				Sweda Limited	Houseware - Kitchenware (Air Fresher; Manufacturer)	SME	http://www.sweda.com.hk/sweda2013/en/home.php
				Team Green / Jigzle*		SME	https://www.greentanet.com/
				Techtronic Industries Company Limited (TTI)	Metal Products - Power Tools & Electronic Equipment	Big	http://www.ttigroup.com/en/home
				Ten Stationery Limited	Lifestyle Products / Metal Products (writing instrument; manufacturer)	SME	https://www.ten-stationery.com/
				The Darts Factory	Metal Products - Darts	SME	https://www.thedartsfactory.com/
				TML (To Make Locally) Apparel Limited (member of Grandion Group)	Fashion & Apparel	Big	http://www.tml-hk.com/landing.htm
				unspun, inc.	Fashion & Apparel - Jeans	SME	http://www.denimunspun.com
				VElove Limited	Fashion & Apparel - Environmental	SME	https://www.velovehk.com/

					Products / Accessories	
				Vocational Training Council - Professional Diploma Programme in Industry 4.0	Vocational Training	Vocational Training Centre (VTC) http://www.vtc.edu.hk/html/en/about/press_1409.html
				Wonderlaine Studio Limited	Design - Consultancy	SME https://www.facebook.com/wbyelainechow/
				Xoopar Limited	Plastic Products / Metal Products - Mobile Accessories	SME http://www.xoopar.com/
				Yick Shun Electronic Toys Manufactory Limited	Toys - Electronic	SME http://www.yickshun.com.hk/
				Zing HK*	Toys	Big
				ZOTAC International Limited*	Houseware - Computer Hardware (Mini PCs & Gaming Graphics Cards)	Big https://www.zotac.com/hk/

Key

*	IDSHK member 香港工業設計師協會會員
	Companies with branches in the ASEAN
	Experts of Industry 4.0
	Experts of Scale Customisation
	In-house Designers
	Non In-house Designers

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