Topics

Topic 1: Human factors and ergonomics

Essential idea: Designers consider three human factors to ensure products meet ergonomic needs.

1.1a Anthropometrics

> Design is human centered and, therefore, designers need to ensure that the products they design are the right size for the user and therefore comfortable to use. Designers have access to data and drawings, which state measurements of human beings of all ages and sizes. Designers need to consider how users will interact with the product or service. Use and misuse is an important consideration.

1.1b Psychological factors

> Human beings vary psychologically in complex ways. Any attempt by designers to classify people into groups merely results in a statement of broad principles that may or may not be relevant to the individual. Design permeates every aspect of human experience and data pertaining to what cannot be seen such as touch, taste, and smell are often expressions of opinion rather than checkable fact.

1.1c Physiological factors

> Designers study physical characteristics to optimize the user's safety, health, comfort and performance

Topic 2: Resource management and sustainable production

2.1 Resources and reserves

Essential idea: Resource management and sustainable production carefully consider three key issues—consumption of raw materials, consumption of energy, and production of waste—in relation to managing resources and reserves effectively and making production more sustainable.

> As non-renewable resources run out, designers need to develop innovative solutions to meet basic human needs for energy, food and raw materials. The development of renewable and sustainable resources is one of the major challenges of the 21st century for designers.

2.2 Waste mitigation strategies

Essential idea: Waste mitigation strategies can reduce or eliminate the volume of material disposed to landfill

> The abundance of resources and raw materials in the industrial age led to the development of a throwaway society, and as resources run out, the many facets of sustainability become a more

important focus for designers. The result of the throwaway society is large amounts of materials found in landfill, which can be considered as a new source to mine resources from.

2.3 Energy utilization, storage and distribution

Essential idea: There are several factors to be considered with respect to energy and design.

Efficient energy use is an important consideration for designers in today's society. Energy conservation and efficient energy use are pivotal in our impact on the environment. A designer's goal is to reduce the amount of energy required to provide products or services using newer technologies or creative implementation of systems to reduce usage. For example, driving less is an example of energy conservation, while driving the same amount but with a higher mileage car is energy efficient.

2.4 Clean technology

Essential idea: Clean technology seeks to reduce waste/pollution from production processes through radical or incremental development of a production system.

Clean technology is found in a broad range of industries, including water, energy, manufacturing, advanced materials and transportation. As our Earth's resources are slowly depleted, demand for energy worldwide should be on every designer's mind when generating products, systems and services. The convergence of environmental, technological, economic and social factors will produce more energy-efficient technologies that will be less reliant on obsolete, polluting technologies.

2.5 Green design

Essential idea: Green design integrates environmental considerations into the design of a product without compromising its integrity.

The starting point for many green products is to improve an existing product by redesigning aspects of it to address environmental objectives. The iterative development of these products can be incremental or radical depending on how effectively new technologies can address the environmental objectives. When newer technologies are developed, the product can re-enter the development phase for further improvement.

2.6 Eco-design

Essential idea: Eco-design considers the design of a product throughout its life cycle (from cradle to grave) using lifecycle analysis.

Consideration of the environmental impact of any product, service or system during its life cycle should be instigated at the earliest stage of design and continue through to disposal. Designers should have a firm understanding of their responsibility to reduce the ecological impact on the planet. Eco-design concepts currently have a great influence on many aspects of design.

Topic 3: Modelling

3.1 Conceptual modelling

> Designers use conceptual modelling to assist their understanding by simulating the subject matter they represent. Designers should consider systems, services and products in relation to what they should do, how they should behave, what they look like and whether they will be understood by the users in the manner intended.

3.2 Graphical modelling

Essential idea: Graphical models are used to communicate design ideas.

> Graphical models can take many forms, but their prime function is always the same—to simplify the data and present it in such a way that understanding of what is being presented aids further development or discussion. Designers utilize graphical modelling as a tool to explore creative solutions and refine ideas from the technically impossible to the technically possible, widening the constraints of what is feasible.

3.3 Physical modelling

Essential idea: A physical model is a three-dimensional, tangible representation of a design or system.

> Designers use physical models to visualize information about the context that the model represents. It is very common for physical models of large objects to be scaled down and smaller objects scaled up for ease of visualization. The primary goal of physical modelling is to test aspects of a product against user requirements. Thorough testing at the design development stage ensures that an appropriate product is developed.

3.4 Computer-aided design (CAD)

Essential idea: A computer-aided design is the generation, creation, development and analysis of a design or system using computer software.

> As technologies improve and the software becomes more powerful, so do the opportunities for designers to create new and exciting products, services and systems. Greater freedom in customization and personalization of products has a significant impact on the end user. The ability to virtually prototype, visualize and share designs enhances the whole design cycle from data analysis through to final designs.

3.5 Rapid prototyping

Essential idea: Rapid prototyping is the production of a physical model of a design using three-dimensional CAD data.

The growth in computing power has had a major impact on modelling with computer-aided manufacture. Rapid software and hardware developments allow new opportunities and exciting new technologies to create dynamic modelling of ever-greater complexity. Models can be simulated by designers using software, tested and trialed virtually before sending to a variety of peripheral machines for prototype manufacture in an ever-increasing range of materials. The ease of sending this digital data across continents for manufacture of prototypes has major implications for data and design protection.

Topic 4: Raw material to final product

4.1 Properties of materials

Essential idea: Materials are selected for manufacturing products based primarily on their properties.

The rapid pace of scientific discovery and new technologies has had a major impact on material science, giving designers many more materials from which to choose for their products. These new materials have given scope for “smart” new products or enhanced classic designs. Choosing the right material is a complex and difficult task with physical, aesthetic, mechanical and appropriate properties to consider. Environmental, moral and ethical issues surrounding choice of materials for use in any product, service or system also need to be considered.

Essential idea: Materials are classified into six basic groups based on their different properties.

4.2a Metals and metallic alloys

Typically hard and shiny with good electrical and thermal conductivity, metals are a very useful resource for the manufacturing industry. Most pure metals are either too soft, brittle or chemically reactive for practical use and so understanding how to manipulate these materials are vital to the success of any application.

4.2b Timber

Timber is a major building material that is renewable and uses the Sun’s energy to renew itself in a continuous cycle. While timber manufacture uses less energy and results in less air and water pollution than steel or concrete, consideration needs to be given to deforestation and the potential negative environmental impact the use of timber can have on communities and wildlife.

4.2c Glass

The rapid pace of technological discoveries is very evident in the manufacture and use of glass in electronic devices. Different properties have been presented in glass for aesthetic or safety considerations for many years but the future of glass seems to be interactivity alongside electronic systems. The structure of glass is not well understood, but as more is learned, its use is becoming increasingly prominent in building materials and structural applications.

4.2d Plastics

Most plastics are produced from petrochemicals. Motivated by the finiteness of oil reserves and threat of global warming, bio-plastics are being developed. These plastics degrade upon exposure to sunlight, water or dampness, bacteria, enzymes, wind erosion and in some cases pest or insect attack, but in most cases this does not lead to full breakdown of the plastic. When selecting materials, designers must consider the moral, ethical and environmental implications of their decisions.

4.2e Textiles

The continuing evolution of the textiles industry provides a wide spread of applications from high-performance technical textiles to the more traditional clothing market. More recent developments in this industry require designers to combine traditional textile science and new technologies leading to exciting applications in smart textiles, sportswear, aerospace and other potential areas.

4.2f Composites

Composites are an important material in an intensely competitive global market. New materials and technologies are being produced frequently for the design and rapid manufacture of high-quality composite products. Composites are replacing more traditional materials as they can be created with properties specifically designed for the intended application. Carbon fiber has played an important part in weight reduction for vehicles and aircraft.

4.3 Scales of production

Essential idea: The scale of production depends on the number of products required.

Decisions on scale of production are influenced by the volume or quantities required, types of materials used to make the products and the type of product being manufactured. There are also considerations of staffing, resources and finance.

4.4 Manufacturing processes

Essential idea: Different manufacturing processes have been developed to innovate existing products and create new products.

Designers sometimes engineer products in such a way that they are easy to manufacture. Design for manufacture (DfM) exists in almost all engineering disciplines, but differs greatly depending on the manufacturing technologies used. This practice not only focuses on the design of a product’s components, but also on quality control and assurance.

4.5 Production systems

Essential idea: The development of increasingly sophisticated production systems is transforming the way products are made.

> As a business grows in size and produces more units of output, then it will aim to experience falling average costs of production—economies of scale. The business is becoming more efficient in its use of inputs to produce a given level of output. Designers should incorporate internal and external economies of scale when considering different production methods and systems for manufacture.

4.6 Robots in automated production

Essential idea: The development of increasingly sophisticated robotic manufacturing systems is transforming the way products are made.

> Designers should consider the benefits of increased efficiency and consistency when using robots in production and be able to explore the latest advances in technology to ensure the optimum manufacturing process is used. However, a good designer will also understand their responsibility to consider the moral and ethical issues surrounding increased use of automation, and the historical impact of lost jobs.

Topic 5: Innovation and design

5.1 Invention

Essential idea: The protection of a novel idea of how to solve a problem is a major factor in commercial design.

> Invention by lone inventors or in collaborative, creative teams is at the forefront of design. Designers must not only be creative and innovative, but also understand the concepts that will make a new product viable. A designer must use imagination and be firmly grounded in factual and procedural knowledge while remembering the needs and limitations of the end user.

5.2 Innovation

Essential idea: There are many different types of innovation.

> Designers will be successful in the marketplace when they solve long-standing problems, improve on existing solutions or find a “product gap”. The constant evaluation and redevelopment of products is key, with unbiased analysis of consumers and commercial opportunities.

5.3 Strategies for innovation

Essential idea: Designers have a range of strategies for innovation.

Companies encourage advancements in technology and services, usually by investing in research and development (R&D) activities. Even though the R&D may be carried out by a range of different experts from varied fields of research, the development process is often based on common principles and strategies to identify the direction of development. This methodology structures the R&D of new technologies and services.

5.4 Stakeholders in invention and innovation

Essential idea: There are three key roles in invention and innovation, which can be shared by one or more people.

Collaborative generation of knowledge and high efficiency information flow allow for diversity, increased resilience, reliability and stability within an organization. Through participatory research, stakeholders can make full use of the resulting innovation and invention, by transferring findings relevant to the sector in which they are positioned. A designer's increased awareness through shared industry knowledge enhances profitability and policy.

5.5 Product life cycle

Essential idea: There are several key stages in the product life cycle.

Designers need to consider the whole product cycle of potential products, services and systems throughout the design cycle and beyond. Products may have an impact not only on the direct consumer but also on society at large and the environment.

5.6 Rogers' characteristics of innovation and consumers

Essential idea: Innovations take time to diffuse into a target audience.

Rogers' four main elements that influence the spread of new ideas (innovation, communication channels, time and a social system) rely heavily on human capital. The ideas must be widely accepted in order to be self-sustainable. Designers must consider various cultures and communities to predict how, why and at what rate new ideas and technology will be adopted.

5.7 Innovation, design and marketing specifications

Essential idea: Successful innovations typically start with detailed design and marketing specifications.

Designers must establish clear parameters for a marketing specification in order to create unique and creative solutions to a problem. Designers need to collect valid and useful data from the target market and audience throughout the design cycle to ensure the specification includes certain essential components.

Topic 6: Classic design

6.1 Characteristics of classic design

Essential idea: A classic design has a timeless quality, which is recognized and remains fashionable.

> A classic design is not simply defined by how well it functions or its impact. Classic designs can be recognized as from their design movement/era. Yet, originality— whether it is evolutionary or revolutionary—seems to be the trait that makes a product “timeless”.

6.2 Classic design, function and form

Essential idea: For a design to become a classic design, the form can transcend the function.

> Classic design holds “form follows function” as a fundamental principle, but this is not always evident in practice. Some products are so well designed with function as their primary goal, that their use is intuitive. As designers develop new technologies, the lines between the form and function of a product continue to blur.

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Topic 7: User-centered design (UCD)

7.1 User-centered design (UCD)

Essential idea: The fundamental principle of UCD is that understanding the needs of the users is the key to designing the best products and services.

> A designer must consider the needs, wants and limitations of the end user within every element of the design cycle. The ability to identify how users will interact with a product, service or system is vital for its success. To achieve this, designers must be able to acquire and analyze valid data without making assumptions about how the product may be used.

7.2 Usability

Essential idea: Usability is about how easy it is to use a product or system.

> A design team should be “user” driven and frequent contact with potential users is essential. To understand how a product, service or system may be used, the designer must consider the prior knowledge and experience of the users, as well as their typical psychological responses. Evaluation methods that utilize appropriate testing and trialing strategies must be used to determine these aspects.

7.3 Strategies for user research

Essential idea: The designer needs to understand the reasons behind the behaviors, wants, and needs of the user.

> Designers should select research strategies based on the desired user experiences in the context of the product, service or system. The purpose of user research is to identify needs that reveal

the complexities of personae. Real-life scenarios that simulate “actual” user experiences can generate new findings.

7.4 Strategies for user-centered design (UCD)

Essential idea: Users have a central role in evaluating whether the product meets their wants and needs.

For designers to successfully integrate usability into the design process, they require a holistic understanding of how a product, service or system is used. Designers must identify user requirements through the use of careful observation and interviews. A clear strategy for UCD will improve acceptability and usability, reducing costs and effort, while fulfilling user requirements.

7.5 Beyond usability—designing for pleasure and emotion

Essential idea: Usability is not the only factor for a designer to consider; products can be designed to evoke pleasure and emotion.

A designer’s ability to provide satisfaction through aesthetic appeal and pleasure can greatly influence the success of a product, service or system. Understanding attitudes, expectations and motivations of consumers plays a significant role in predicting product interaction. Designers need to be empathetic and sympathetic to user emotion, which acts as a critical component to determine how he or she interprets and interacts with a product, service or system.

Topic 8: Sustainability

8.1 Sustainable development

Essential idea: Sustainable development is concerned with satisfying human needs for resources now and in the future without compromising the carrying capacity of the planet.

Designers utilize design approaches that support sustainable development across a variety of contexts. A holistic and systematic approach is needed at all stages of design development to satisfy all stakeholders. In order to develop sustainable products, designers must balance aesthetic, cost, social, cultural, energy, material, health and usability considerations.

8.2 Sustainable consumption

Essential idea: Sustainable consumption focuses on reducing the use of resources of a product to minimize its environmental impact.

Designers develop products, services and systems that satisfy basic needs and improve quality of life. To meet sustainable consumption requirements, they must also minimize the use of natural resources, toxic materials and waste, and reduce emissions of pollutants at all stages of the life cycle.

8.3 Sustainable design

Essential idea: Sustainable design is a philosophy of developing products in line with social, economic, and ecological sustainability principles.

> The first step to sustainable design is to consider a product, service or system in relation to eco-design and analyze its impact using life cycle analysis. The designer then develops these to minimize environmental impacts identified from this analysis. Considering sustainability from the beginning of the process is essential.

8.4 Sustainable innovation

Essential idea: Sustainable innovation facilitates the diffusion of sustainable products and solutions into the marketplace.

> Sustainable innovation yields both bottom line and top line returns as developing products, services and systems that are environmentally friendly lowers costs through reducing the resources required. Designers should view compliance with government legislation as an opportunity for sustainable innovation.

Topic 9: Innovation and markets

9.1 Corporate strategies

Essential idea: Companies and businesses can utilize a range of different strategies to develop products, services and systems.

> The success of a company relies heavily on the strategies it adopts. The evaluation of products, services and systems can inform the selection of the most appropriate strategies to follow that will enable a company to achieve its objectives.

9.2 Market sectors and segments

Essential idea: Designers must research and consider the target market sectors and segments in the design of their products.

> Designers must consider the market when targeting their product, service or system. The smaller the sector, the more the target audience will have in common. Companies may decide to compete in the whole market or only in segments that are attractive and/or familiar. A designer's understanding of the identified market is essential.

9.3 Marketing mix

Essential idea: The marketing mix is often crucial when determining a product or brand's offering.

> Empathy for, and understanding of the target audience is developed through thorough analysis of the market chosen. This informs several factors: the standards that end users demand; how

and where to distribute and sell the product; how much they are willing to pay for a certain product and its quality; and how to communicate the launch of a product. Correct analysis of these factors could determine the success or failure of a product, despite its quality.

9.4 Market research

Essential idea: Market research is any organized effort to gather information about markets or customers.

Market research often identifies how to improve the product, service or system and increase its chance of success within a particular sector or segment. The price a user is prepared to pay is usually determined through market research. This in turn sets an upper limit of cost to the design and production of a potential product, service or system. Market research has a crucial role in determining the constraints a designer has to work within.

9.5 Branding

Essential idea: Branding creates an identity for a product or company, which makes it distinct from another and can provide added value.

In order to diffuse products into the marketplace, the identity of a company is typically embodied in a brand. The brand is communicated to the consumer through a value proposition. Designers help to communicate this by: building a strong user experience around the brand identity; determining content design; establishing the tone of message through advertisements; promotion.

Topic 10: Commercial production

10.1 Just in time (JIT) and just in case (JIC)

Essential idea: Just in time and just in case are opposing production strategies utilized by the manufacturer.

While inventory creates a safety net for companies, maintenance and potential waste of resources can have significant implications for companies and the environment. Manufacturers must evaluate and analyze each market and determine whether a JIT or JIC strategy is the best to follow

10.2 Lean production

Essential idea: Lean production aims to eliminate waste and maximize the value of a product based on the perspective of the consumer.

Lean production considers product and process design as an ongoing activity and not a one-off task, and should be viewed as a long-term strategy.

10.3 Computer integrated manufacturing (CIM)

Essential idea: Computer-integrated manufacturing uses computers to automatically monitor and control the entire production of a product.

> When considering design for manufacture (DfM), designers should be able to integrate computers from the earliest stage of design. This requires knowledge and experience of the manufacturing processes available to ensure integration is efficient and effective. Through the integration of computers, the rate of production can be increased and errors in manufacturing can be reduced or eliminated, although the main advantage is the ability to create automated manufacturing processes.

10.4 Quality management

Essential idea: Quality management focuses on producing products of consistent required quality.

> Designers should ensure that the quality of products is consistent through development of detailed manufacturing requirements. They also need to focus on the means to achieve it. The importance of quality management through quality control (QC), statistical process control (SPC) and quality assurance (QA) reduces the potential waste of resources.

10.5 Economic viability

Essential idea: Designers must consider the economic viability of their designs for them to gain a place in the market.

> Designers need to consider how the costs of materials, manufacturing processes, scale of production and labor contribute to the retail cost of a product. Strategies for minimizing these costs at the design stage are most effective to ensure that a product is affordable and can gain a financial return.