Consumer Product Design

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Chapter - 1

Introduction to Product design

Product design is the process of creating a new product to be sold by a business to its customers.

Product design in another word is the set of properties of an artefact, consisting of the discrete properties of the form (i.e., the aesthetics of the tangible good and/or service) and the function (i.e., its capabilities) together with the holistic properties of the integrated form and function.

- **Product design** is the process of creating a new product, modifying old product and withdrawing old product to be sold by a business to its customers.
- **Service design:** Specifies what physical items, physical benefits and psychological benefits the customer is to receive from the service.

Product design as a verb is the process of creating a new product to be sold by a business to its customers. A very broad concept, it is essentially the efficient and effective generation and development of ideas through a process that leads to new products.

Product design is conceptualization of an idea about a product and transformation of the idea into a reality. To transform the idea into reality a specification about the product is prepared. This specification is prepared by considering different constraints such as production process, customer expectation, etc. In product design stage every aspects of the product are analyzed. Also final decision regarding the product is taken on the basis of the analysis. This decision can be any aspect related to the product, e.g. dimension and tolerances, type of material for every components, etc.

Objectives of Product Design

- To ensure growth of the organization
- To utilize the surplus capacity of the organization, such as physical facility, man power, etc.
- To utilize the surplus fund of the organization

- To meet new requirement of the customers
- To increase company's market share and to target new market segment
- To ensure complete product range in company's portfolio

Features of a good product design

- ✓ **Functionality:** The product must function properly for intended purpose.
- ✓ **Reliability:** The product must perform properly for the designated period of time.
- ✓ **Productivity:** The product must be produced with a required quantity and quality at a defined and feasible cost.
- ✓ **Quality:** The product must satisfy customer's stated and unstated needs.
- ✓ **Standardization:** The product should be designed in such a fashion so that most of the components are standardized and easily available in the market.
- ✓ **Maintainability:** The product must perform for a designated period with a minimum and defined maintenance. Adequate provision for maintenance should be kept in the product.
- ✓ **Cost effectiveness:** The product must be cost effective. The must be manufactured in the most cost effective environment.

Steps of product design

- ➢ **Synthesis:** Try to develop different alternatives
- ➢ **Sketching:** Draw sketches in exact scale for different alternatives
- ➢ **Analysis:** Analysis different alternatives with respect to operability, maintainability, inspection, assembling and dismantling issues, cost parameters, production methos, etc.
- ➢ **Selection:** Select the best alternative
- ➢ **Basic engineering:** Prepare layout in exact scale, calculate strength of components, select proper cost effective materials.
- ➢ **Detail design:** Prepare detail engineering drawing for each component
- ➢ **Prototype:** If option is there, then prepare prototype and test it

- **Manufacturing:** If prototype is not made, then follow manufacturing steps and solve manufacturing problems and assembly problems, if any.
- **Operation:** collect feedback during actual operation of the new product. If any problem exists, try to provide design based solution. Also, implement lessons in the future design.
- **Product development:** If any modification can be done, implement the same in the next generation product.

Trends in Product Design

- Product designers need to consider all of the details: the ways people use and abuse objects, faulty products, errors made in the design process, and the desirable ways in which people wish they could use objects. Many new designs will fail and many won't even make it to market. Some designs eventually become obsolete.
- The design process itself can be quite frustrating usually taking 5 or 6 tries to get the product design right. A product that fails in the marketplace the first time may be re-introduced to the market 2 more times. If it continues to fail, the product is then considered to be dead because the market believes it to be a failure. Most new products fail, even if it's a great idea.
- All types of product design are clearly linked to the economic health of manufacturing sectors. Innovation provides much of the competitive impetus (energy) for the development of new products, with new technology often requiring a new design interpretation. It only takes one manufacturer to create a new product paradigm to force the rest of the industry to catch up - fueling further innovation.
- Products designed to benefit people of all ages and abilities—without penalty to any group—accommodate our swelling aging population by extending independence and supporting the changing physical and sensory needs we all encounter as we grow older.

Product and Service Design

Organizations that have well-designed products or services are more likely to realize their goals than those with poorly designed products or services.

Objectives of product and service design are profit, competitive, customer satisfaction and quality.

Trends in product and service design:

- Profit

  Low cost

  Less material and less packaging
- Customer satisfaction

  Capabilities of production and delivery
- Competitive

  Reduced production time

  Reduced introduction lead time
- Quality

  Environmental concern, including waste minimization, recycling parts, and disposal of worn out products

  User friendly
- Other reasons for product and service design

  Creating an image of being a market leader

  Customer complaints

  Accidents or injuries

  Excess warranty claims

  Low demand

Source of design ideas

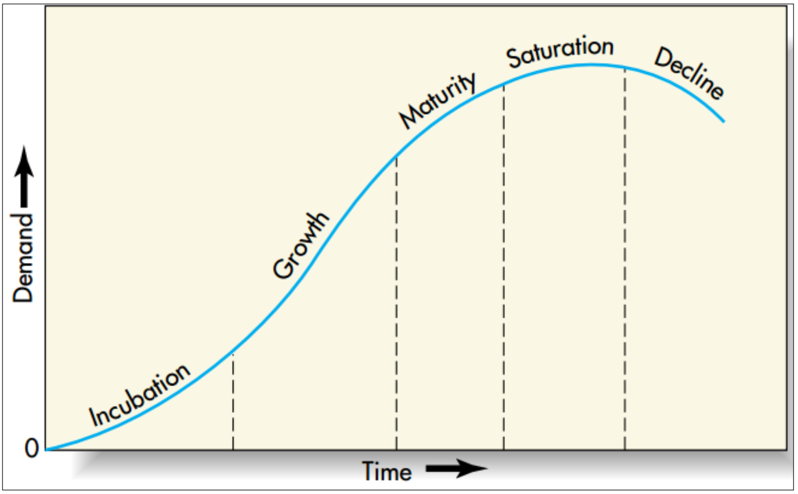
- Marketing, such as the use of focus groups, surveys, and analyzes of buying patterns.
- Research and development, involving basic research, applied research, and development from universities, research foundations, government agencies, and private enterprises.
- Basic research has the objective of advancing the state of knowledge about a subject without any near-term expectation of commercial applications.
- Applied research has the objective of achieving applications.
- Development converts the results of applied research into useful commercial applications.

- Benefits come from licensing and royalties of patents with potentially high cost. Because product innovations made by US companies have ended up being produced competitively by foreign companies with better processes, some companies are shifting to a much-balanced approach that explores both product and process R&D.
- Competitors

Key design concerns

- Translate customer wants and needs into product and service requirements. (marketing)
- Product capabilities, including equipment, skill, material, schedule, technology, and other special abilities.
- Manufacturability, for products, ease of fabrication and/or assembly and, for services, ease of
- Providing services in cost, productivity, and quality.
- Standardization, the extent to which there is the absence of variety in a product, service, or process.
- Benefits: low design cost, low production cost, increased productivity, easy replacement and repair, reduced training time and cost, improved quality control, opportunities for a long production run and automation, and routine purchasing, accounting, scheduling, and inventory handling.
- Disadvantages are reduction in variety, less consumer appeal, resistance to improvement, increased expenditure for the perfect design, premature design freeze (e.g., typewriter keyboard).
- Communication and agreement among design, production or operations, and marketing.
- Legal or regulatory consideration from Food and Drug Administration, Environmental Protection Agency, National Highway Safety Commission, and Consumer Protects Safety Commission. [Construct and test prototypes (marketing, operations)]
- Product liability, a manufacturer is liable for any injury or damage caused by a faulty product.
- Uniform commercial code, products carry an implication of merchantability and fitness.
- Document specifications.
- Life-cycle factors.

Product Design Issues



Product Life Cycle

1. **Incubation**
   - Most expensive for a company launching a new product
   - The size of the market is small
   - Sales are low, although they will be increasing
   - Expectation of price drops
   - Cost of things like (research and development, consumer testing, and the marketing) needed to launch the product can be very high (competitive sector)
2. **Growth**
   - Characterized by a strong growth in sales and profits
   - To invest more money in the promotional activity
3. **Maturity**
   - Few design changes
   - Most competitive time
4. **Saturation**
   - Period of stagnation
   - Most of the consumer have already used the product
   - Less innovation to offer

5. **Decline**

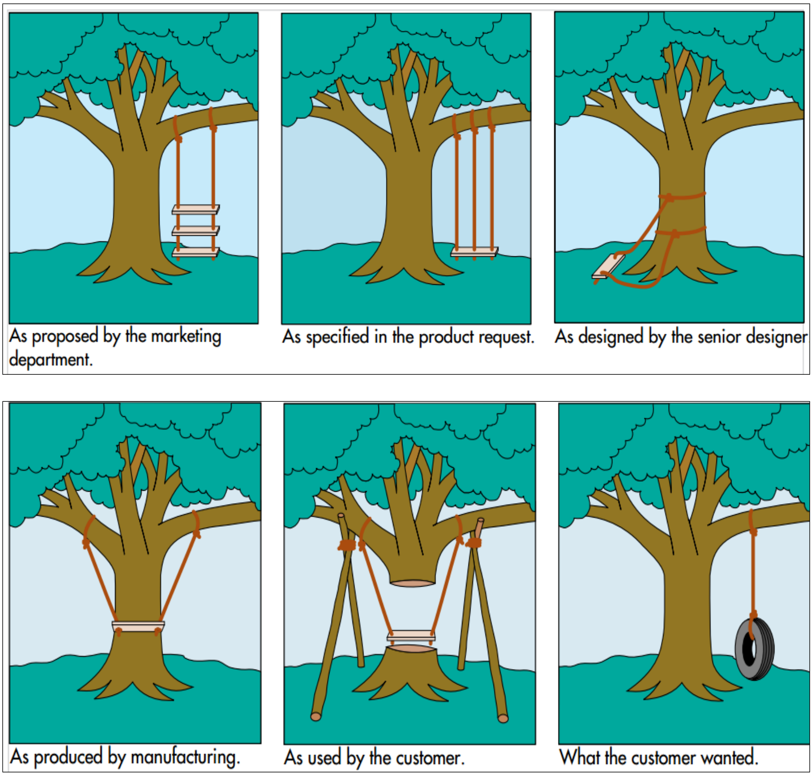
- Market for a product will start to shrink
- Inevitable
- Can switch to less-expensive production methods and cheaper markets

Some products do not exhibit life cycles, e.g., wooden pencils, paper clips, knives, drinking glasses etc.

Strategies to prolong product life cycle

- Reliability improvement
- Reduced cost and price
- Product redesign
- Packaging change

Need for product design



The design process follows a guideline involving three main sections:

1. Analysis
2. Concept
3. Synthesis

The latter two sections are often revisited, depending on how often the design needs touch-ups, to improve or to better fit the criteria. This is a continuous loop, where feedback is the main component.

1. Analysis

- **Accept Situation:** Designers decide on committing to the project and finding a solution to the problem. Pool the resources into figuring out how to solve the task most efficiently.
- **Analyze:** In this stage, everyone in the team begins research. They gather general and specific materials which will help to figure out how their problem might be solved. This can range from statistics, questionnaires, and articles, among many other sources.

2. Concept

- **Define:** This is where the key issue of the matter is defined. The conditions of the problem become objectives, and restraints on the situation become the parameters within which the new design must be constructed.

3. Synthesis

- **Ideate:** The designers here brainstorm different ideas, solutions for their design problem. The ideal brainstorming session does not involve any bias or judgment, but instead builds on original ideas.
- **Select:** By now, the designers have narrowed down their ideas to a select few, which can be guaranteed successes and from there they can outline their plan to make the product.
- **Implement:** This is where the prototypes are built, the plan outlined in the previous step is realized and the product starts to become an actual object.
- **Evaluate:** In the last stage, the product is tested, and from there, improvements are made. Although this is the last stage, it does not mean that the process is over. The finished prototype may not work as well as hoped so new ideas need to be brainstormed.

Manufacturing Design

- ✓ **Design for manufacturing (DFM):** Designs take into account the organization's capabilities when designing a product.
- ✓ **Design for recycling (DFR):** Design facilitates the recovery of materials and components in used products for reuse.
- ✓ **Design for assembly (DFA):** Design focuses on reducing the number of parts in a product and on assembly methods and sequence.
- ✓ **Design for dis-assembly (DFD):** Design so that used products can be easily taken apart (using snap fits wherever possible).
- ✓ **Robust design:** Design that result in products or services that can function over a broad range of conditions and eventually results in higher level of customer satisfaction.
    - ▪ Robust product design is a concept from the teachings of Dr. Genichi Taguchi, a Japanese quality guru. It is defined as reducing variation in a product without eliminating the causes of the variation. In other words, making the product or process insensitive to variation. Achieve major advance in product or service design fairly quickly using a relatively small number of experiments. Using proper parameter design, a classical design of $2^{12} = 4096$ combinations can be reduced to 32 combinations to reach an optimal design.
- ✓ **Modular design:** A form of standardization in which component parts are subdivided into modules that are easily replaced or interchanged. It shares the pros and cons of standardization. Any failure is easy to diagnose and remedy but, if a part of a module fails, the entire module must be scrapped.
- ✓ **Concurrent engineering (simultaneously development):** Bringing manufacturing design and manufacturing personnel together early in the design phase to achieve a smooth transition from product design to production, and to decrease product development time. The group can be enlarged to include suppliers and marketing and purchasing personnel.

Design guidelines

1. Determine the nature and focus of the service and the target market
2. Determine customer requirements and expectations
3. Determine the degree of customer contact and customer involvement

in the system

4. Have a single and unifying theme to help personnel to work together
5. Make sure the system has the capability to handle any expected variability in service requirements
6. Make sure the system will be reliable and will provide consistently high quality
7. Design the system to be user-friendly.

Chapter - 2

Key concepts of Product Design

Standardization

An important issue that often arises in both product/service design and process design is the degree of standardization. Standardization refers to the extent to which there is the absence of variety in a product, service, or process. Standardized products are made in large quantities of identical items; calculators and computers are examples. Standardized service implies that every customer or item processed receives essentially the same service. Standardized processes deliver standardized service or produce standardized goods.

Advantages

1. Fewer parts to deal with in inventory and in manufacturing.
2. Reduced training costs and time.
3. More routine purchasing, handling, and inspection procedures.
4. Orders fillable from inventory.
5. Opportunities for long production runs and automation.
6. Need for fewer parts justifies increased expenditures on perfecting designs and improving quality control procedures.

Disadvantages

1. Designs may be frozen with too many imperfections remaining.
2. High cost of design changes increases resistance to improvements.
3. Decreased variety results in less consumer appeal.

Design for manufacturability (also sometimes known as design for manufacturing or DFM) is the general engineering art of designing products in such a way that they are easy to manufacture. The concept exists in almost all engineering disciplines, but the implementation differs widely depending on the manufacturing technology. DFM describes the process of designing or engineering a product in order to facilitate the manufacturing process in order to reduce its manufacturing costs. DFM will allow potential problems to be fixed in the design phase which is the least expensive place to address them. Other factors may affect the manufacturability such as the type of raw material, the form of the raw material, dimensional tolerances, and secondary processing such as finishing. Depending on various types of manufacturing processes there are set guidelines for DFM practices. These DFM guidelines help to precisely define various tolerances, rules and common manufacturing checks related to DFM.

Extent to which a good can be manufactured with relative ease at minimum cost and maximum reliability.

Mass customization is a marketing and manufacturing technique that combines the flexibility and personalization of "custom-made" with the low unit costs associated with mass production. At its core is a tremendous increase in variety and customization without a corresponding increase in costs. At its limit, it is the mass production of individually customized goods and services. At its best, it provides strategic advantage and economic value. Mass customization is the process of delivering wide-market goods and services that are modified to satisfy a specific customer need.

Prototyping is essential for clarifying information requirements. The design of a system (functional specs) must be finalized before the system can be built. A prototype is an early sample, model, or release of a product built to test a concept or process or to act as a thing to be replicated or learned from. It is a term used in a variety of contexts, including semantics, design, electronics, and software programming.

Functionability is the quality or state of being functional; especially: the set of functions or capabilities associated with computer software or hardware or an electronic device.

Creativity is a quality that is highly valued, but not always well understood. Those who have studied and written about it stress the importance of a kind of flexibility of mind. Studies have shown that creative individuals are more spontaneous, expressive, and less controlled or inhibited. They also tend to trust their own judgement and ideas-- they are not afraid of trying something new.

A common misunderstanding equates creativity with originality. In point of fact, there are very few absolutely original ideas. Most of what seems to be new is simply a bringing together of previously existing concepts in a new way. Psychologist and author Arthur Koestler referred to this merging of apparently unrelated ideas as bissociation. The fact that creative thinking is based on a knowledge of previous work in one's field is the justification for teaching the history and foundations of a given field as a resource for future research and creative work. It is possible to develop ones ability to think intuitively and creatively. The exercises assigned in this class are in part intended to expand these skills.

Thus creativity is the ability to see connections and relationships where others have not. The ability to think in intuitive, non-verbal, and visual terms has been shown to enhance creativity in all disciplines. It has also been shown that the creative process is very similar in all fields.

Essentially the design process is a problem-solving process, and the designer, just like the laboratory scientist, will be most successful if the problem is approached in a systematic manner. Successful fine artists generally follow the same pattern in developing their creative ideas, though they may be less conscious of the process they are following. Initially the researcher or designer/artist will tend to experiment in a rather random manner, collecting ideas and skills through reading or experimentation. Gradually a particular issue or question will become the focus of the reading and experimentation. The next step is to formulate a tentative problem, and begin to explore that topic. Eventually the problem is refined into a research question or design problem that the person will then pursue through repeated experimentation. In design or fine arts production, this takes the form of works created in a series. Each effort solves certain problems, and suggests issues to be dealt with in the next work (or experiment). Working in a series is the most important stage of the design process. The ability to experiment, to value and learn from mistakes, and build on the experience achieved is the hallmark of a truly successful and creative individual, whatever the field.

Modular Design

Modular design is a form of standardization. Modules represent groupings of component parts into subassemblies, usually to the point where the individual parts lose their separate identity. An example of modular design is computers which have modular parts that can be replaced if they become defective. For mass customization, modular design enables producers to quickly assemble modules to achieve a customized configuration for an individual customer, avoiding the long customer wait that would occur if individual parts had to be assembled.

One advantage of the modular design of equipment compared with the non-modular design is that failures are often easier to diagnose and remedy because there are fewer pieces to investigate. Similar advantages are found in ease of repair and replacement; the faulty module is conveniently removed and replaced with a good one. The manufacture and assembly of modules generally involve simplifications: fewer parts are involved, so purchasing and inventory control become more routine, fabrication and assembly operations become more standardized, and training costs often are relatively low.

The main disadvantages of modular design stem from the decrease in variety: the number of possible configurations of modules is much less than the number of possible configurations based on individual components. Another disadvantage that is sometimes encountered is the inability to disassemble a module in order to replace a faulty part; the entire module must be scrapped—usually at a higher cost.

The essential requirements of a good product design are listed as follows:

1. Product must optimally perform its main function (task).
2. It must be easy to repair at a low repair cost.
3. It must be very reliable to use.
4. It must follow principles of aesthetics.
5. It must be a durable one.
6. It can be easily produced in large numbers at minimum production cost.
7. It must be simple to produce and use (handle).
8. It must also be compact.

1. Function

The product must be designed in such a way that it optimally performs the main task or function for which it is purchased by a buyer. In other words, the product must satisfy the needs and wants of the consumer.

For e.g. the main function of an Air Conditioner (AC) is to provide quick cooling of a room. So, AC must be designed in such a way that it can cool a room as fast as technologically possible. If it doesn't meet basic expectations, the consumers won't buy it.

2. Repairability

The product must be designed in such a way that it can be easily repaired whenever necessary during a malfunction. The product repairs must be done quickly that too at a low repair cost. Consumers usually don't buy those costly products, which are either very expensive to repair / maintain or those who take a longer time and more money for repairing.

3. Reliability

Reliability means dependability on a product. Consumers prefer to purchase and use often those products which perform their main function or task optimally for a longer period without any annoying malfunctions, breakdowns or failures. In short, a product must perform quite well and give trouble-free service for a decent amount of time. It must not need constant repairs and/or frequent maintenances. It is so, since repairs often turn costly and are very time consuming. Reliability is crucial for consumer durables and office equipment. A reliable product gains consumers' trust, loyalty and this creates its goodwill in the competitive market. Therefore, reliability is an important factor to be kept in mind while designing a product.

4. Aesthetics

Aesthetics must be kept in mind while designing a product. It refers to, how the product looks, feels, sounds, tastes or smells. That is, the product must look, feel, sound, taste or smell very good. It must be attractive, compact and convenient to use. Its packaging must also be made graphically appealing and colourful. If this aspect is not considered, product will fail in the market. This factor is very important, especially in case a product is designed for and targeted to the young generation that is emerging with a modern mindset and current trends.

5. Durability

Durability refers to the life of a product. A durable product performs flawlessly for a longer period. It is a sign of a good-quality product. Consumers want their products to have a longer life. They do not want to replace their products repeatedly. This factor is very crucial for durable and costly products like televisions, refrigerators, cars, so on. Therefore, durability is another important requirement that must be kept in mind while designing a product.

6. Producibility

The product must be designed in such a way that it can be produced in large quantities with ease at a minimum production cost. The production department must be able to produce the product easily, quickly, in ample quantities and at a low production cost. The production process must not be very complex, and it must not require costly machines to produce the product.

7. Simplicity

The design of the product must be very simple. The simpler a design, the easier, it is to produce and use (handle). Simple products are also economical and reliable. The product must have the least number of operations without affecting its functionality.

8. Compact

The product must be small; it must occupy less space, and must have lower weight. In other words, it must be very compact. The company must try to make its products as small as possible. Today, everything is turning smaller. Big sized cell phones are now out of fashion. In the 1950s, computers were as huge as spacious rooms. However, today we have laptops and palmtop computers. Most products can be made compact. Still, this cannot be done for all products. In case of televisions, it is just the opposite. Today people want bigger televisions. Similarly, there is a limit on small size. We cannot have a phone which is so tiny that it requires a microscope to see its keypad.

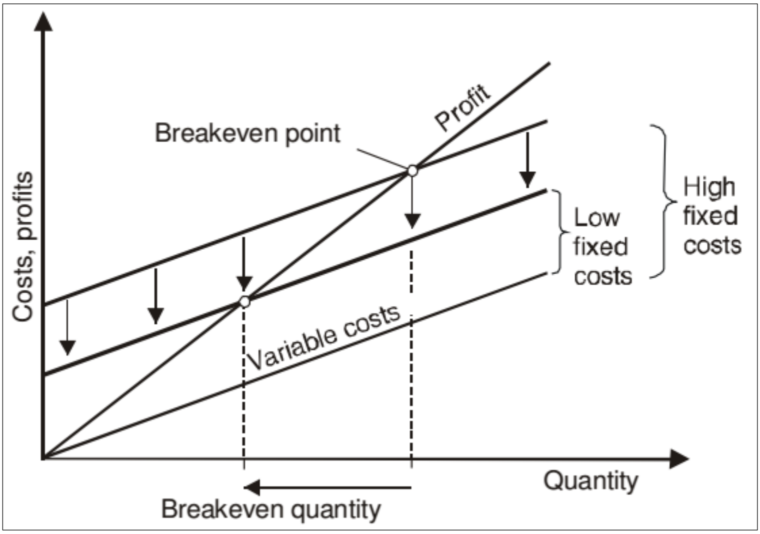
Steps of product design

1. **Synthesis:** Try to develop different alternatives
2. **Sketching:** Draw sketches in exact scale for different alternatives
3. **Analysis:** Analysis different alternatives with respect to operability, maintainability, inspection, assembling and dismantling issues, cost parameters, production methos, etc.
4. **Selection**: Select the best alternative
5. **Basic engineering:** Prepare layout in exact scale, calculate strength of components, select proper cost-effective material.
6. **Detail design:** Prepare detail engineering drawing for each component
7. **Prototype:** If option is there, then prepare prototype and test it
8. **Manufacturing:** If prototype is not made, then follow manufacturing steps and solve manufacturing problems and assembly problems, if any.
9. **Operation:** collect feedback during actual operation of the new product. If any problem exists, try to provide design-based solution. Also, implement lessons in the future design.
10. **Product development:** If any modification can be done, implement the same in the next generation product.

Chapter - 3

Cost Analysis and Cost Reduction

The review and evaluation of the separate cost elements and profit (including cost or pricing data or information other than cost or pricing data), and the application of judgement to determine how well the proposed costs represent what the cost of the contract should be, assuming reasonable economy and efficiency.

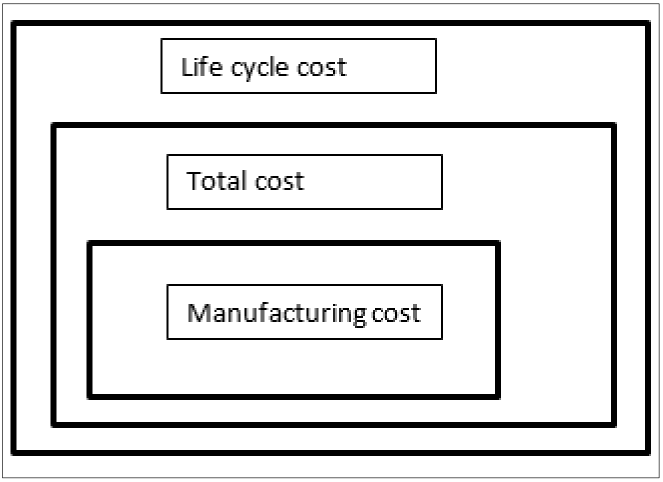


The profit (P) is the difference the total revenue (TR) and the total cost (TC). The volume at which the total cost (TC) and the total revenue (TR) are equal, i.e., P=0, is referred to as the break-even point (BEP). When the output volume is less than the break-even point, there is a loss. When the output volume is greater than the break-even point, there is a profit. Greater the deviation from this point, greater the profit or loss.

Cost Reduction

The challenges of the marketplace are met by product developers in two ways: development of innovative products and reducing product costs. Cost reduction alone is not a substitute for innovation. Cost-oriented product development is systematic engineering work, which requires an interdisciplinary approach, and needs to be efficient and effective.

Among costs, the greatest importance is attributed to lowering manufacturing costs, usually within the framework of the most cost-efficient possible product development. The lowering of costs is only one aspect of the problem; it is just as important to mold the company structure so that market changes can be reacted to quickly and flexibly, and that innovation is encouraged.



This is a process to reduce their costs and increase their profits. Depending on a company’s services or product, the strategies can vary.

Companies typically launch a new product without focusing too much on cost. Cost becomes more important when competition increases and price becomes a differentiator in the market.

Principles of cost reduction are well established. These begin with a classification of costs: manufacturing costs, total costs and lifecycle costs. We then proceed with the methods of cost reduction in each of the areas. Cost management is necessary in the development of innovative and high performance products - products about which customers would be enthusiastic, and which fulfil the market requirements. It makes more sense to lower the costs right at the beginning of product development, rather than afterwards by the usual steps of personnel reduction when the costs are found too high.

Management's primary goal in cost reduction is to lower the fixed costs. On one hand, their goal is to improve the company's earning power, since a considerable part of a company's reserves are in its fixed costs (frequently more than 50% of its total costs). Concurrently, the breakeven quantity with which the company can generate profits is lowered, so there is more flexibility. By doing so, the company gains product development freedom in the market and becomes more resistant to market fluctuations.

Reducing Product Costs

Reduce complexity

It may be that unnecessary complexity is a primary cost driver when it comes to product development. In many companies, for example, products and product lines develop independently of each other, with engineers focusing on the task at hand.

When business is good and everyone is busy, there is little time to go back through previous projects to see if any existing components match the requirements of the new product. Unfortunately, engineers don't have easy access to or knowledge of products developed in the past, other than to try to find someone who may recall working on a similar project.

Slower periods are an opportunity to deploy engineers to work on the complexity problem by creating "a virtual parts bin" which can give members of the engineering team access to the company's engineering legacy. This makes it possible to go back and not only uncover redundancy, but to also use their time to improve the company's products by reducing weight and volume or introduce alternative materials that may not have been available when the product was initially designed. With a "virtual parts bin," both the development/engineering cycle and costs can be reduced.

Reduce prototype development time

Although putting 3-D digital prototyping technology to work has a multitude of advantages, ranging from lowering costs, speeding up the prototyping process and fostering innovation, there are engineers who continue to rely on creating physical prototypes. Unfortunately, the process creates bottlenecks, so engineers find themselves waiting around until the next prototype is finished. The costs are simply too high, both in time and money, for this to occur today.

With the absolute requirements of maximum efficiency, lowest possible costs and getting to market in record time, management can help overcome engineering department reluctance by taking two steps: make a commitment to move to digital prototyping, and follow up by investing in the technology and training that makes the transition successful. Key elements in using virtual prototyping for effectiveness: ensuring that design reviews happen digitally and that all involved stakeholders learn to think "digitally" (making key decisions using only the digital prototype).

Use more technology

Along with prototype building, technology offers other benefits. Technology can also speed up what has long been the time-consuming, tedious and costly sign off process. There is no reason to distribute physical sets of drawings, when it can be done digitally. Changes and comments can be noted electronically and redistributed, if necessary, to say nothing of identifying any stragglers who have yet to respond. New technology is always easier to deploy when the organization is not running at full-speed. Many successful companies have used downturns to their advantage by choosing to introduce new technologies and processes when the going is slow.

Make better use of suppliers

It's critical that suppliers be part of the team at the start of a project. The results can be positive when this occurs. By involving suppliers from the beginning, companies can make significant contributions as unpaid "consultants."

Listen to the people on the line

Those assembling a product, whether it's a vehicle, a grill or a computer, may be the engineers' most useful resource. Unfortunately, they receive too little attention and recognition. It should not be surprising that they often feel inadequate when asked for suggestions. All of which demands a culture change, since their input can be of tremendous value in avoiding problems and improving a product.

Think like a customer when it comes to features

It's easy to forget that the task is satisfying customers, not the engineers or designers.

It doesn't need to happen. Apple, Inc. understood that most cell phone users hated their phones for the same reasons that plagued the iDrive. While cell phones are technological marvels, they are essentially user-unfriendly. The intuitive iPhone avoided the iDrive error as in the case of BMW and quickly became an unparalleled success.

Design for cost savings

Design for cost savings but don't sacrifice testing and verification. It's only necessary to point to huge product recalls, as well as spec changes on certain parts soon after a product has been introduced, to validate this issue. Whether the problem is caused by the need to meet an introduction deadline or to abide by an ultimatum to reduce overall development costs, the result can be a costly disaster.

Create and rationalize specifications

If this seems painfully obvious, then why are there so many exceptions, and costly mistakes? If, for one reason or another, a supplier happens to change specifications, how can they be held responsible if there were no approved specs?

Beyond that, manufacturers need to have specs for all their products. It's no accident or plain luck that the design and specifications for all BMW brakes (considered one of the most confidence-inspiring designs under driving conditions) are the same. The only difference is in the size.

Cost reduction strategies

- Supplier consolidation
- Component consolidation
- Low-cost country sourcing
- Request for quotations (RFQ)
- Supplier cost breakdown analysis
- Function cost analysis / Value analysis / Value engineering
- Design for manufacture / Design for assembly
- Reverse costing
- Cost driver analysis
- Product benchmarking
- Design to cost
- Design workshops with suppliers
- Competitor benchmarking

Chapter - 4

Cost economics and Value Analysis

A. Product cost must be computed based on Total Cost that quantifies all costs, including overhead costs, and rationally allocates all appropriate costs to every product variation.

1. Total cost measurement complies all the cost for every product variation that, when subtracted from the selling price, yields the true profit, which is the only way to compute realistic profitability. Being able to sort all product variations by true profitability can provide:

- An objective basis for product portfolio planning that will prioritize resources based on developing products with highest expected return from given resources.
- An objective basis for rationalizing away money-losing products

2. Total Cost encourages behavior that actually minimizes total cost – meaning all costs.

3. Without total cost, new product development efforts are in danger of being compromised and penalized in three ways:

- Product development resources may be diluted pursuing too many products that may all appear equally rewarding, which is statistically unlikely. On the other hand, total cost measurements will better estimate profitability, thus enabling development efforts to be prioritized on only the highest return efforts
- Resources may be drained away from product development teams to build unprofitable existing products that true profitability metrics should have been identified and rationalized away.
- When the new product is launched, it will have to pay a loser tax to subsidize all the unprofitable products, thus raising the new product's selling price, which, in turn, will make it less competitive.

B. Avoid counterproductive policies that inhibit or thwart good product development such as overloading Engineering with low-profit new development projects, "taking all orders" and "accepting all customizations" for existing product variations, deadline "management" (which can be counterproductive if poorly set deadlines don't encourage thorough up-front work), not quantifying total cost, trying to remove cost after the product is designed, low-bidding on custom parts, and offshoring to "save cost," which prevents Engineering working together with Manufacturing (concurrent engineering).

After DFM training, one large company that had pioneered many of these, needed to launch an initiative called "DFM vs policy" to correct current counterproductive policies for their first product development team to utilize these new methodologies.

Value Analysis

It is an orderly and creative method to increase the value of an item. The item can be a product, a system, a process, a procedure, a plan, a machine, equipment, tool, a service or a method of working. Value Analysis, also called Functional Analysis was created by L.D. Miles of General electric Company.

The value of an item is how well the item does its function divided by the cost of the item (In value analysis value is not just another word for cost):

Value of an item = performance of its function/cost

An item that does its function better than another, has more value. Between two items that perform their function equally well, the one that costs less is more valuable.

"Value Analysis can be defined as a process of systematic review that is applied to existing product designs in order to compare the function of the product required by a customer to meet their requirements at the lowest cost consistent with the specified performance and reliability needed."

Key points and elements

1. Value Analysis is a systematic, formal and organized process of analysis and evaluation. It is not haphazard or informal and it is a management activity that requires planning, control and co-ordination.
2. The analysis concerns the function of a product to meet the demands or application needed by a customer. To meet this functional requirement the review process must include an understanding of the purpose to which the product is used.
3. Understanding the use of a product implies that specifications can be established to assess the level of fit between the product and the value

derived by the customer or consumer.

4. To succeed, the formal management process must meet these functional specification and performance criteria consistently in order to give value to the customer.

5. In order to yield a benefit to the company, the formal review process must result in a process of design improvements that serve to lower the production costs of that product whilst maintaining this level of value through function.

To value analyse anything, a study group of 4 to 6 persons formed, preferably each with different knowledge, with different backgrounds (cross-functional). They meet in a room free from interruptions. Then the item to be studied selected. The item should be one that gives the impression that its cost is too high or that it does not do its function well. All brainstorming ideas are put on a white board. All ideas are acceptable.

The value analyst should always be aware of functions, not of products, shapes, or processes. The main function is what the item does, is that which somebody wanted to archive by creating the item. Express this function (if possible) with just two words, a verb and a noun. If the item is composed of various parts, it is useful to ask for the function of each part, and how they contribute to the main function of the item. Do not be distracted by mere aggregate functions such as the rubber on a pencil's end or the ice producing part of a refrigerator. These were functions added since it was economical or easy to do so. They have no relationship with the main function.

Chapter - 5

Socio-Technical and Ergonomic Factors in Design of Products

Socio-technical and ergonomic factors in Design of Products

Anthropometric, ergonomic, psychological, physiological considerations in design decision making, legal factors, engineering ethics and society.

Ergonomics is the study of the interaction between the human body, products and the surrounding environment. It is a key factor in the design of all products from furniture to handheld gadgets. It is an essential part of the design process.

The main objective for ergonomists is to improve consumer's lives by increasing their comfort when using products.

When ergonomics is incorporated into industrial machinery and tooling it can increase efficiency, productivity and reduce errors and accidents. The principles of ergonomics involve designers understanding how humans interact and with products. The methods of focussing on human performance take either a quantitative approach or a qualitative approach.

The quantitative approach relates to the physical fit of the human body in relation to speed of performance and workload. The qualitative approach relates to the overall comfort experienced by the user. Everyday situations can be hazardous to health by persistently subjecting the human body to positions and situations that are not comfortable. In western countries, musculoskeletal system (e.g. lower back pain) and psychological illness (e.g. stress) lead to the greatest significance of absenteeism from work. These conditions can be caused by poor quality ergonomic design of equipment. Therefore in the workplace, improved ergonomics can increase productivity. Posture and movement are two of the most important factors in considering ergonomic design. Success of everyday tasks is closely related to good posture and efficient movement. Ligaments, tendons and muscles of the body constantly adapt to positions that the body subjects them to. Quite often, products that possess poor ergonomic characteristics subject the user to mechanical stress on joints and muscles.

Environmental factors influencing ergonomics

• Noise; • Illumination; • Vibration; • Climate; • Chemical substances.

Anthropometrics: is the use of body measurements to determine the optimum size for products for comfortable and efficient use. Examples of anthropometric data include:

- How far people can reach;
- How much space people need;
- How much force they can exert;
- Height of a person;
- Length of arms/legs etc.

Many production companies use anthropometric data when designing. The designer's aim is to achieve as good an anthropometric match for as many potential consumers as possible.

Biomechanical and anthropometrical data are closely linked when designing products. A number of areas and factors must be considered when planning size and shape of products, especially those related to posture and movement.

For the design of work-based products, some of the main biomechanical principles of importance to ergonomics and anthropometrics are listed below:

- Joints must be in a neutral position.
- Keep the work close to the body.
- A twisted trunk strains the back and upper body.
- Sudden movements produce peak stresses.
- Alternate postures as well as movements and positions.
- Limit the duration of continuous movement.
- Prevent muscular fatigue.
- Frequent short breaks are preferred to one long break.
- Limit energy expenditure in individual tasks.
- After heavy tasks, rest is essential.

The background of anthropometrics Anthropometry is related to the size and proportions of the human body. Important anthropometric principles are listed below:

1. **Be aware of differences in body size.** Designers of various products must bear in mind the differences in body shape and size of users. For example a table height that is suitable for an average person might be unsuitable for a tall or short person. A solution might be to make the height of the table adjustable to cater for the comfort of a wider range of sizes of users. Sometimes products must be designed to suit the extremes of human size, e.g. a control panel that has to be reached should be reachable by a user with the shortest arms. Another example might be that seating in a plane must cater for the leg space of the tallest passengers.

2. **Use anthropometric tables that are appropriate for specific populations.** Data related to some population groups is not always relevant to other population groups, e.g. the average height of an adult in the UK is relatively tall compared with average world population. Height data of humans will often refer to unshod persons and therefore 3-5cms will need to be added if relevant to the design of a specific product. When designing the ergonomic aspects of a product, system or environment for human use we must consider three different areas.-

    1. Anthropometrics
    2. Physiology
    3. Psychology

Designers produce products to be used by the majority of the population – to design a product that can be used by everyone would be impossible or impractical. When selecting sizes for various anthropometric factors of a product we must consider the age, sex and race of the users who will be using it.

For different aspects of a design we would consider different percentile ranges.-

Aspect	Percentile	Why	Example
Clearance	95% Male	Biggest	Length of handles, Width on an armchair, Height of doors.
Reach	5% Female	Smallest	Grip diameter, distance to back of a cupboard, height of a coat hook.
Posture, Comfort or Movement	50% Male	Average	Height of work surfaces, Distance between steps.

Designing in this way is known as the ‘Method of Limits. ‘People who have to be considered separately are from the recorded percentile ranges are.-

1. The very small
2. The very tall
3. The elderly
4. The handicapped
5. Pregnant women
6. Children

Physiology is the study of.-

Factor	Example
Body Strength	The amount of weight that we can lift in various positions, the amount of force which we can apply when pulling or pushing in different positions and with different parts of the body. (Also How far we can throw a certain weight, How far we can jump!!!)
Fatigue	How long the body can the stresses and strains of different positions and tasks before tiring (may involve additional weight), how far and fast we can run before tiring. (See also Posture and Movement below)
Reaction Times	How long it takes the body to react to a given stimulus. E.g. if a driver needs to break suddenly how long does it take them to release the accelerator pedal, move their foot the required distance and press the brakes.
Posture	The stresses placed on the body and its shape while sitting and standing. The angle of the arm and hand when holding objects in different positions.
Movement and Dexterity	The range of movements that the body can make in different positions, and their accuracy. The strains placed upon the body while lifting, carrying pulling and pushing.

These are all Physiological considerations which must be taken into account when designing.

Psychology

Psychology is the study of how we react to different stimulus in our surrounding environment (heat, light, noise, colour, texture, contrast and pattern) through the use of our senses.-

1. Sight
2. Touch
3. Sound
4. Taste
5. Smell

When designing products we make use of visual, audio and textural sensations to inform the user that a task has been carried out or to draw their attention to something (To convey important information).

When carrying out an operation sensations should be used to reinforce their use or to let the user know that they have carried out an operation properly. It should be obvious how to carry out a task or how to use a product through its use of shape, colour and contrast.

Colour affects us by making us feel calm or aggressive and by making objects seem heavier, lighter or faster.

Factors and Considerations

The difference between an ergonomic factor and an ergonomic consideration is crucial in analysing products

<table>
<tr><th colspan="2">Ergonomic Factor</th><th colspan="2">Ergonomic Considerations</th></tr>
<tr><td colspan="2">An ergonomic factor is a part of a product which has to be designed with reference to an aspect of ergonomics, to ensure the ease of use of the product.</td><td colspan="2">An ergonomic consideration is a human factor which has to be investigated and used in developing the product being designed.</td></tr>
<tr><td colspan="4">Mobile Phone</td></tr>
<tr><td>Anthropometric Factor</td><td>Width of Button.</td><td>Anthropometric Consideration</td><td>Width of Human Finger.</td></tr>
<tr><td>Physiological Factor</td><td>Positioning of buttons in relation to the shape of the phone.</td><td>Physiological Consideration</td><td>Range of movements available to the hand and digits in that position.</td></tr>
<tr><td>Psychological Factor</td><td>User must know when a button has been pressed properly.</td><td>Psychological Consideration</td><td>There is a noise / a change in the pressure needed to press the button down / a change on the screen.</td></tr>
</table>

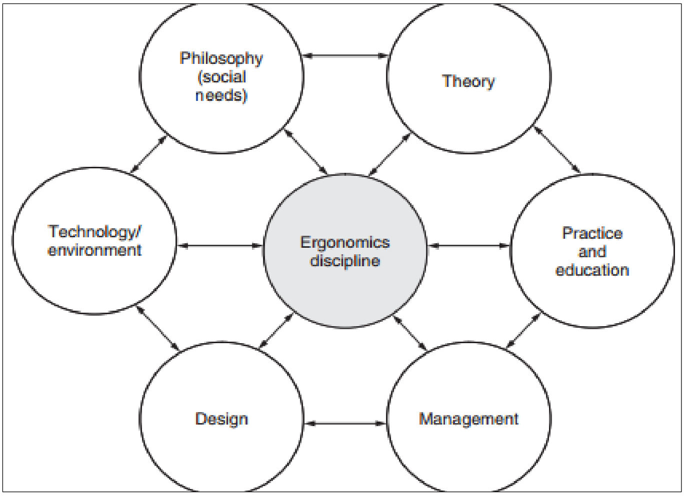
Product Design: is one of the most important non price factors which determine the success of a product. The role of product design changes throughout the lifecycle of a product. In the initial product development stage, the role of design is to create a marketable product from an innovation. The product may create a need where none existed before, (for example when the Sony Walkman was introduced) or quite different products may be competing with others in the same market. As the product life cycle matures, more competitors enter the market and the chief role of design is in product differentiation through quality, appearance, performance, ease of use, reliability, reparability and so on.

The importance of design as a non-price factor and the role of design in determining the production and running costs of a product lies in the theory that:

1. A purchaser will chose a better designed, higher quality product when given the choice of two products of similar price.
2. A purchaser will chose the cheaper of two products of similar design and quality.

In reality, purchaser choice will also be influenced by various other non-prices factors such as availability, advertising, company image, and ideology (for example, nationally produced or environmentally friendly products. In addition, price is often regarded as an indication of quality. Finally, purchasers can also choose between a product or a service (for example a washing machine or a laundry). A number of studies have shown that innovativeness and technical sophistication are the non-price factors which most determine competitive success in international markets. While product design is generally considered to be a non-price factor it also important to consider the influence of design upon product price. Product design effects the cost of production through the choice and use of materials and how the product is assembled (known as Design for Manufacture). Design also influences after sales maintenance and running costs (which is more important for some types of products such as heating systems). Running costs are often calculated as being integral to the price of a product in purchasers decisions. Therefore it is simplistic to view design as purely a non- price factor.

The field of design can cover almost everything from lipsticks to locomotives, from paper clips to space shuttles. Product designs with different considerations have different orientations for their processes and goals. Market-oriented product design makes possible the combination of art, technology and market, and the combination of product development and economic benefits. On the other hand, manufacture and cost-oriented product design takes into account the recovery of costs and the reduction of production costs. Whereas user-centered design (UCD) focuses on the consideration of users' operability, comfort and participation to develop products that can best satisfy users' needs. The initial observation of the study found that long-time use of products with longer service lives might lead to users' physiological discomfort or the problem of unsuitable functions. One of the examples is furniture whose service life often reaches up to 20 years. Nearly all of the in-home furniture are of fixed type and users will have to accustom themselves to the original design of the furniture which cannot be adjusted according to the changes of times environments. This may lead to the problems of users' discomfort or furniture's unsuitability. To solve the problem of the discomfort caused by long-time use of furniture, this article attempted to come up with a dynamic design concept for furniture that can take into consideration users' physiological changes. It is hoped that through the development and application of an innovative approach, a UCD method and its application can be established.



Socially Responsible Design "takes as its primary driver social issues, its main consideration social impact and its main objective social change. Perhaps the earliest call for industrial designers to be conscious of the impacts of their work was made by the activist professor Victor Papanek He advocated that industrial designers can go beyond "appearance design", styling, or "design cosmetics", and use their talents to solve the pressing needs of disadvantaged minorities in society: the disabled, the elderly, the communities in the developing world, and others often ignored by the design profession. He believed that "the only important thing about design is how it relates to people He advocated that market-oriented designers should contribute a tenth of their time or income on socially conscious projects.

In the 1980s and 1990s responsibility in the design industry was embodied in the new terms “Eco design” and “green design”. Environmentally conscious design was used to communicate to consumers that designers and manufacturers are showing some concern about the lifecycle impacts of designed objects on the planet. Most Eco design approaches were of a technical nature, such as reducing materials or energy, light weighting, avoiding toxics during production or usage, and recyclability. Particularly in the European Union, directives and regulations to protect the environment helped ensure that designers conformed to technical requirements on manufacturing, materials, distribution, energy consumption, and end-of-life. Consumer demand for green and greener products went up, marking a distinctive societal change. Socially sustainable design goes beyond the ecological by exploring solutions that can positively change the lives of people everywhere.

Universal design, inclusive design, design-for-all, barrier-free design, accessible design–which all meant designing products that are inherently usable by as many people as possible, whether able-bodied or physically challenged, without need for adaptation–emerged as another design philosophy of this period, especially as a result of the passing of national laws aimed at reducing discrimination against people with disabilities.

Chapter - 6

Legal factors

Choosing a new design

There are a variety of different legal and non-legal issues to consider when deciding on a new appearance/design for a product. Often the legal aspects get overlooked.

Before adopting a new appearance/design for a product, at the very least it is essential that we think about the following two legal issues:

- If I use this new appearance/design will I infringe someone else's earlier legal rights (e.g. their registered design)?
- Will I be able to get a registered design for my new design, thus making it easier for me to stop others from using my design or something similar?

Both issues can be addressed through conducting pre-use clearance searches, investigations and taking preliminary legal advice.

Why is it important to consider the legal issues?

When choosing and adopting a new design for a product, many businesses fail to appreciate that they ought to carry out pre-use clearance searches and investigations.

Pre-use clearance searches will help to determine whether the use of your proposed new design would result in you infringing someone else's legal rights in an identical or similar registered design.

If we do not carry out searches and investigations we run the risk of using a design that someone else has an earlier legal right to use and/or to prevent us from using our design. Holders of registered and unregistered designs can take legal proceedings against anyone who uses an identical or very similar design. Such proceedings can be extremely serious for a client's business and expensive to defend and/or resolve. If legal proceedings are successful, a defendant is normally prevented from continuing to use their design and may have to pay large sums in damages to compensate the earlier design owner. A defendant would normally also have to bear the earlier design owner's legal costs, as well as its own legal costs.

On top of any damages and legal costs that you might end up having to pay, there is nothing worse than having to go to the cost and effort of a re-design, especially when it is a mere month or two after your new product design was first launched to the public and to the trade. In a world where reputation is increasingly driven by social media, having to conduct a re-design because of legal pressure from a third party earlier rights owner could easily result in a major loss of customer goodwill, damage to your brand reputation and provide your competitors with an advantage, which could have been avoided.

Businesses can devote a great deal of time and money to their design, production and marketing plans, before they realise that another business has an identical or similar product design that can prevent them using their proposed design. Conducting clearance searches and investigations at the outset can help to avoid this possibility. Usually this will involve carrying out (as a minimum) a UK and Community registered design search, to see whether your proposed design (or a very similar design) is already registered. In addition, internal investigations will ascertain what designs 'inspired' your own design team to produce the proposed new product design (i.e. did they copy someone else's design?). It is possible that a third party may have earlier 'unregistered' rights in a design, which would not be revealed by a search of the UK and Community registered designs register, but which could prevent you from using your new design.

Pre-use clearance searches will help to assess the chances of your design achieving registration as a registered design.

Pre-filing searches and investigations can help avoid a situation where a business has incurred the cost of filing a registered design application, which must subsequently be abandoned due to another business' earlier rights. For example, they should hopefully reveal whether someone else has an earlier registered design, which they could rely on to prevent the registration of your design.

Owners of earlier registered and unregistered designs can rely on their rights in order to invalidate design registrations that are identical or very similar to their designs. If invalidity proceedings are successful, your design registration would be invalidated and you would normally have to bear the earlier design owner's legal costs, as well as your own legal costs.

What is a registered design?

Registered designs are designs that are recorded on a public register, which prevent another trader from being able to use the same design. They can also stop another trader from using a very similar design. They are negative, monopoly rights.

In order to obtain a registered design you have to file an application at a national registry (e.g. the United Kingdom Intellectual Property Office), or at OHIM if you wish to obtain a Community registered design, or via WIPO if you want an international design. You also have to pay official filing and publication fees. Once registered, provided that you pay your renewal fees every 5 years, a UK or Community registered design will normally last for 25 years from the date of filing the application.

What can you register as a registered design?

A registered design protects the two-dimensional and/or three-dimensional appearance of the whole or part of a product, resulting from the features of, in particular, the lines, contours, colours, shape, texture or materials of the product or its ornamentation.

What can't you register as a registered design?

We cannot register:

- Designs that are not 'new' (i.e. An identical design, or a design whose features differ only in immaterial details, to one that has been made available to the public beforehand).
- Designs that lack 'individual character' (i.e. If the overall impression it produces on the informed user does not differ from the overall impression produced on such a user by any design which has been made available to the public beforehand).
- Features of appearance of a product that are solely dictated by the product's technical function, or which permit the product to be connected to another product, so that either product may perform its function.
- Thus, when deciding what product design to use and adopt, you ought to consider whether you will be able to get a registered design for that product design. Without registered design protection you may struggle to prevent other traders from using the same design, or something very similar.

Why is design registration important?

There are four main advantages to registering your design as a registered design:

What is the difference between registered designs and unregistered designs?

The fundamental difference is that registered designs give you a monopoly right, whilst unregistered designs do not.

- You are informing the world at large of your legal rights in the design. Registered design registers are open to public inspection. Businesses can use such registers to check if a design they plan to use is owned by someone else and warns them off.
- Registration helps to raise awareness of your design. After all, a design is a valuable asset of your business that you can license to a third party, sell to a purchaser of your design, or a purchaser of your business.
- Registration makes it easier to prevent others from using the same or very similar designs. Registration helps to dissuade others from trading using the same or a very similar design. It is surprising how often this actually happens in practice.
- Registration will prevent somebody else from registering your design, or something very similar, and then accusing you of infringing their registered design.

When you consider the likely cost and damage to your business if somebody else started trading using your product designs, or something very similar, registration offers excellent value for money insurance cover. If you don't register your product designs as registered designs, you will have to rely on whatever rights you may have in your 'unregistered' designs, in order to try to stop someone from copying your design. Broadly speaking, a registered design gives you a much easier and broader legal right to enforce than any rights you may have in an unregistered design. The monopoly granted by registered design means that if someone else uses the same or a very similar design then they will be infringing your legal rights, *whether or not they knew of your design.* You would not have to prove that the infringer copied your design.

Conversely, unregistered designs don't give you a monopoly in your product design. If someone else uses the same or a very similar design then they will not automatically be infringing your legal rights. To succeed in proving unregistered design infringement, you have to show that the alleged infringer knew of your design and that they copied it. In the UK and across the European Union, unregistered designs are commonly protected via the law of

Community unregistered design, UK unregistered design right and/or overseas copyright laws. These rights arise automatically, but they don’t last anywhere near as long as registered designs (in the UK 10 years maximum, often only 3 years, and for the last 5 years of any 10 year term you must licence the design to any competitor who wishes to use it). Unregistered designs also often only protect certain features of a design and the protection is narrower than that of a registered design. In summary, registered designs offer you better protection against third party imitators and are thus more valuable to businesses.

Chapter - 7

Design analysis and implementation

What is Design and Implementation?

Design and implementation is the fourth phase of the project cycle, subsequent to value chain selection, value chain analysis and designing the competitiveness strategy. While is it useful to separate these phases for the purposes of discussion, in practice many of the techniques and skills used in selection, analysis and strategy development are continually applied during implementation. Further, while these stages of the project cycle are sequential, they are not linear: it is essential that analysis continues during the implementation phase, in order to guide modifications to the competitiveness strategy in response to changes in the market, the enabling environment or the chain itself.

The competitiveness strategy that informs project design is not just a plan for helping individual firms become more profitable, it is a road map for moving an industry toward higher, sustained rates of growth. It provides a vision of competitiveness and an upgrading plan for the industry that helps us understand ***what*** needs to be done to upgrade the industry, *who* the relevant stakeholders are and what each of them needs to do, and *how* the industry will attain the vision.

Many value chain development programs in the past have focused on alleviating specific constraints by introducing improved production technology, providing financial and business support services or improving the policy environment. The aim of the value chain approach articulated here is to *facilitate* actions that build capacity internal to the value chain to enable private-sector stakeholders to become and remain competitive without continued external support. To achieve this, value chain programs must draw on the vision of competitiveness to develop:

- An industry pathway to guide interventions in support of this vision,
- A knowledge management system to enable deviations from the pathway to inform ongoing and future interventions, and
- A plan for scaling up impact and removing support prior to exiting.

Why Intervene

All interventions should flow from a project's goals and objectives, and for value chain projects the goal is increased competitiveness that benefits MSEs and the poor. The aim of a project intervention should therefore be to result in one or more of the following:

- **An increased number of actors building broader and deeper commercially grounded networks:** Will the intervention encourage existing value chain actors and new entrants to establish effective relationships in the value chain, supporting markets and/or enabling environment?

  Example: By assisting commercial agricultural input firms to test and roll out more appropriate business models for targeting the smallholder market a USAID project in Zambia was able to get 12 input firms to establish over 1,200 new relationships with rural smallholder communities resulting in smallholder investments of over $1 million in their farms in 2008.

- **Increased competition based on upgrading and innovation:** Will the intervention increase the number of value chain or support market actors that are constantly upgrading?

  Example: A project in India helped several supermarket chains to move beyond a price-only strategy for local sourcing of fresh produce. The new focus on product quality drove farm-level upgrading and encouraged investments in the production of specialty produce.

- **Improved credibility of and confidence in market mechanisms through transparent and reasonable benefit flows:** Will the intervention increase the transparency and appropriateness of benefit flows to all contributing actors in the value chain and supporting markets?

  Example: As grafting and pruning services began to generate demand among smallholder avocado growers in Kenya, the industry realized that a self-accreditation program was necessary to set apart trained service providers who used only certified and labeled quality scions from more unscrupulous and untrained "quack" service providers. Accreditation guaranteed a set of minimum standards for service delivery, such as the commitment to provide an additional free grafting should the first service fail, thus ensuring that smallholder farmers benefited from the services they received.

- **Improved key end market factors that will increase competitiveness--in terms of product, operations and branding:** Will the intervention improve the specific value chain products, operations and/or branding strategies required to increase the capacity of the industry to differentiate itself from its competitors?

Design production system: modular design

Modular design

Modular design, or modularity in design, is a design theory and practice that subdivides a system into smaller parts called *modules* (such as modular process skids), which can be independently created, modified, replaced or exchanged between different systems.

A modular design can be characterized by functional partitioning into discrete scalable and reusable modules, rigorous use of well-defined modular interfaces, and making use of industry standards for interfaces. In this context modularity is at the component level, and has a single dimension, component slot ability. A modular system with this limited modularity is generally known as a platform system that uses modular components. Examples are car platforms or the USB port in computer engineering platforms.

In design theory this is distinct from a modular system which has higher dimensional modularity and degrees of freedom. A modular system design has no distinct lifetime and exhibits flexibility in at least three dimensions. In this respect modular systems are very rare in markets. Mero architectural systems are the closest example to a modular system in terms of hard products in markets. Weapons platforms, especially in aerospace, tend to be modular systems, wherein the airframe is designed to be upgraded multiple times during its lifetime, without the purchase of a completely new system. Modularity is best defined by the dimensions effected or the degrees of freedom in form, cost, or operation.

Modularity offers benefits such as reduction in cost (customization can be limited to a portion of the system, rather than needing an overhaul of the entire system), interoperability, shorter learning time, flexibility in design, non-generationally constrained augmentation or updating (adding new solution by merely plugging in a new module), and exclusion. Modularity in platform systems, offer benefits in returning margins to scale, reduced product development cost, reduced O&M costs, and time to market. Platform systems have enabled the wide use of system design in markets and the ability for product companies to separate the rate of the product cycle from the R&D paths. The biggest drawback with modular systems is the designer or engineer.

Most designers are poorly trained in systems analysis and most engineers are poorly trained in design. The design complexity of a modular system is significantly higher than a platform system and requires experts in design and product strategy during the conception phase of system development. That phase must anticipate the directions and levels of flexibility necessary in the system to deliver the modular benefits. Modular systems could be viewed as more complete or holistic design whereas platforms systems are more reductionist, limiting modularity to components. Complete or holistic modular design requires a much higher level of design skill and sophistication than the more common platform system.

Cars, computers, process systems, solar panels, wind turbines, elevators, furniture, looms, railroad signaling systems, telephone exchanges, pipe organs, synthesizers, electric power distribution systems and modular buildings are examples of platform systems using various levels of component modularity. For example, one cannot assemble a solar cube from extant solar components or easily replace the engine on a truck or rearrange a modular housing unit into a different configuration after a few years, as would be the case in a modular system. The only extant examples of modular systems in today's market are some software systems that have shifted away from versioning into a completely networked paradigm.

Modular design inherently combines the mass production advantages of standardization, since modularity is impossible without some level of standardization, (high volume normally equals low manufacturing costs) with those of customization. The degree of modularity, dimensionally, determines the degree of customization possible. For example, solar panel systems have 2-dimensional modularity which allows adjustment of an array in the x and y dimensions. Further dimensions of modularity would be introduced by making the panel itself and its auxiliary systems modular. Dimensions in modular systems are defined as the effected parameter such as shape or cost or lifecycle. Mero systems have 4-dimensional modularity, x, y, z, and structural load capacity. As can be seen in any modern convention space, the space frame's extra two dimensions of modularity allows far greater flexibility in form and function than solar's 2-d modularity. If modularity is properly defined and conceived in the design strategy, modular systems can create significant competitive advantage in markets. A true modular system does not need to rely on product cycles to adapt its functionality to the current market state. Properly designed modular systems also introduce the economic advantage of not carrying dead capacity, increasing the capacity utilization rate and its effect on cost and pricing flexibility.

Chapter - 8

Design Models- Principles in design for Manufacturability and Assembly

Product development is the process of creating a new product to be sold by a business or enterprise to its customers. In the document title, *Design* refers to those activities involved in creating the styling, look and feel of the product, deciding on the product's mechanical architecture, selecting materials and processes, and engineering the various components necessary to make the product work. *Development* refers collectively to the entire process of identifying a market opportunity, creating a product to appeal to the identified market, and finally, testing, modifying and refining the product until it is ready for production. A product can be any item from a book, musical composition, or information service, to an engineered product such as a computer, hair dryer, or washing machine. This document is focused on the process of developing discrete engineered products, rather than works of art or informational products.

Definitions

On the basis of design goal: product design involves assembly lines, use of interchangeable parts, and standardization of parts and components with a view towards reducing product cost.

Function and functional representation of design: Dictionaries define function as: working, action; and the action of something. The definition encompasses any of the specific roles possessed by each mutually interacting element constituting a whole. While functionality is considered an intuitive concept, dependent on the designer’s intention.

Design for Manufacturability and Assembly

Design for Manufacturing and Assembly (DFMA) is a design philosophy used by designers when a reduction in part count, a reduction in assembly time, or a simplification of subassemblies is desired. It can be used in any environment regardless of how complex the part is or how technologically advanced this environment may be. It is gaining popularity where manufacturing costs are a concern. DFMA encourages concurrent engineering during product design so that the product qualities reside with both designers and the other members of the developing team.

Design for manufacturing (DFM) and design for assembly (DFA) are the integration of product design and process planning into one common activity. The goal is to design a product that is easily and economically manufactured.

DFMA is utilized by hundreds of domestic and international companies in an effort to cut down concurrent manufacturing and assembly time. Domestic companies like Allied-Signal, Motorola, Hughes Aircraft, and McDonnell Douglas Corporation have already implemented the DFMA philosophy throughout their product lines. The DFMA implementation process may be done at two different stages: when a new design requirement is established or when an existing design requires product optimization, such as the case of the Longbow Apache Helicopter. At the initial design stage, the designer develops a simplistic conceptual design by envisioning an assembly that requires a minimum of parts to perform the requirements previously established, and is easy to install. In the second stage the designer redesigns existing assemblies or designs new assemblies in order to implement design optimizations to ease manufacturing, and installation. This also meets reliability and maintainability requirements, moving the design towards cost reduction and customer satisfaction. In order to maximize the benefits of DFMA the designer must have a good working knowledge of the manufacturing processes available, and process capabilities to produce the parts. The design and manufacturing elements must work closely to determine the best manufacturing approach. A review of the State-of-the art manufacturing processes which increase the effectiveness of DFMA provides a means to understand this synergism, as well as the availability of Statistical Process Capabilities (SPC).

Principles in Design for Manufacturability and Assembly

The heart of any design for manufacturing system is a group of design principles or guidelines that are structured to help the designer reduce the cost and difficulty of manufacturing an item. The following is the list of these rules.

1. Reduce the total number of parts

The reduction of the number of parts in a product is probably the best opportunity for reducing manufacturing costs. Less parts implies less purchases, inventory, handling, processing time, development time, equipment, engineering time, assembly difficulty, service inspection, testing, etc. some approaches to part-count reduction are based on the use of one-piece structured and selection of manufacturing processes such as injection molding, extrusion, precision casting, and powder metallurgy, among others.

2. Develop a modular design

The use of modules in product design simplifies manufacturing activities such as inspection, testing, assembly, purchasing, redesign, maintenance, service and so on.

3. Use of standard components

Standard components are less expensive than custom made items. The high availability of these components reduces product lead times. Also, their reliability factors are well ascertained. Furthermore, the use of standard components refers to the production pressure to the supplier, relieving in part the manufacture's concern of meeting production schedules.

4. Design parts to be multi- functional

Multi-functional parts reduce the total number of parts in a design, thus, obtaining the benefits given in rule 1.

Also, there can be elements that besides their principal function have guiding, aligning or self-fixturing features to facilitate assembly, and/or reflective surfaces to facilitate inspection, etc.

5. Design parts for multi- use

In a manufacturing firm, different products can share parts that have been designed form multi- use. These parts can have the same or different functions when used in different products. In order to do this, it is necessary to identify the parts that are suitable for multi-use. For example, all the parts used in the firm (purchased or made) can be stored into two groups: the first containing all the parts that are used commonly in all products. After organizing all the parts into part families, the manufacturing processes are standardized for each part family. The production of a specific part belonging to a given part family would follow the manufacturing routing that has been setup for its family, skipping the operations that are not required for it. Furthermore, in design changes to existing products and especially in new product designs, the standard multi-use components should be used.

6. Design for ease of fabrication

Select the optimum combination between the material and fabrication process to minimize the overall manufacturing cost. In general, final operations such as painting, polishing, finishing machine, etc. should be avoided. Excessive tolerance, surface finish requirements, and so on is commonly found problems that result in higher than necessary production cost.

7. Avoid separate fasteners

The use of fasteners increases the cost of manufacturing apart due to the handeling and feeding operations that have to be performed. Besides the high cost of the equipment required for them, these operations are not 100% successful, so they contribute to reduce the overall manufacturing efficiency. N general, fasteners should be avoided and replaced, for example, by using tabs or snap fits. If fasteners have to be used, then some guides should be followed for selecting them.

8. Minimize assembly directions

All parts should be assembled from one direction. If possible, the best way to add parts is from above, in a vertical direction, parallel to the gravitational direction (downward). In this way, the effects of gravity help the assembly process, contrary to having to compensate for its effect when other directions are chosen.

9. Maximize compliance

Errors can occur during insertion operations due to variations in part dimentions or on the accuracy of the positioning device used. This faulty behavior can cause damage to the part and/or to the equipment. For this reason, it is necessary to include compliance in the part design and in the assembly process.

10. Minimize handling

Handling consists of positioning, orienting and fixing a part or component. To facilitate orientation, symmetrical parts should be used whenever possible. If it is not possible, then the asymmetry must be exaggerated to avoid failures. Use external guiding features to help the orientation part of a part. The subsequent operations should be designed so that the orientation of the part is maintained.

Also, magazines, tube feeders, part strips and so on, should be used to keep this orientation between operations. Avoid using flexible parts- use slave circuit boards instead. If cables have to be used, then include a dummy connector to plug the cable (robotic assembly) so that it can be located easily. When designing the product, try to minimize the flow of material waste, parts and so on, in the manufacturing operation; also, take packaging into account, select appropriate and safe packaging for the product.

10 general design principles:

1. Simplicity
2. Standard Materials and Components
3. Standardized Design of the Product
4. Liberal Tolerances

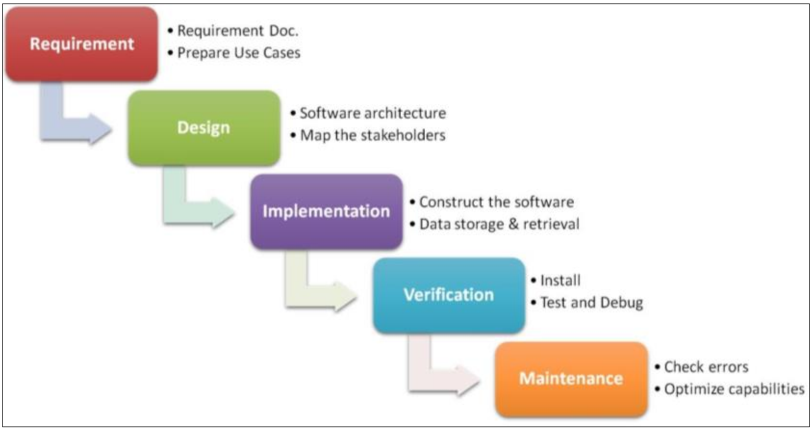
5. Use Materials that are Easy to Process
6. Teamwork with Manufacturing Personnel
7. Avoidance of Secondary Operations
8. Design to Expected Level of Production
9. Utilize Special Process Characteristics
10. Avoid Process

Design Models and Methods

A model offers its user a means of comprehending an otherwise incomprehensible problem. Models help us to visualize the problem, to break it down into discrete, manageable units. The value of a specific model is determined within the context of use. Like any other instrument, a model assumes a specific intention of its user. A model should be judged by how it mediates the designer's intention, how well it can share a work load, and how effectively it shifts focus away from itself toward the object of the design activity. A methodology's process describes the work to be done and the order in which it is to be done.

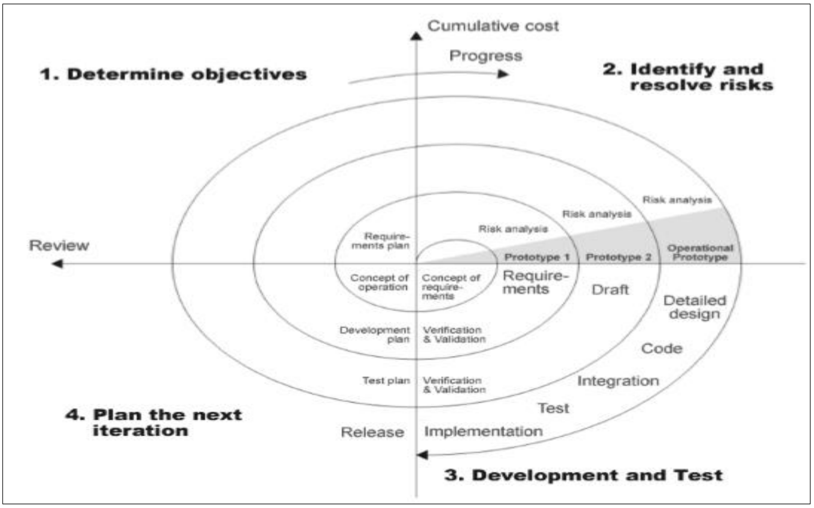
Sequential or Waterfall Process

This is the simplest methodology consist of a set of sequential activities in which the outputs of each step are the inputs to the next (the "waterfall"). This approach makes sense for small, well-defined problems in a stable context. Its goal is to "get everything right before progressing to next step" to minimize rework, which assumes complete and clear requirements that can be validated at each step.



Iterative Process Model

Other methodologies are more iterative or recursive, and assume that rework is inevitable and desirable. An underlying assumption is that requirements and the problem and solution contexts can only be understood over time, so it isn't worth investing too much effort to "pin them down" early in the design process. The goal of iterative methods is "get enough right at each step to know which step to take next". Prototyping is essential; products emerge throughout the process and quality steadily improves. “Spiral Methodology” is a iterative process model.



Agile Process Methodology

"Agile" or "extreme programming" methods for software development have become very popular methods in the last decade and are a specialized form of iterative methods used by small design teams. These methods deprecate up-front investment in scoping and requirements specification, and rely on very rapid coding and testing cycles to incrementally develop software. The "Agile Manifesto" (agilemanifesto.org) advocates:

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

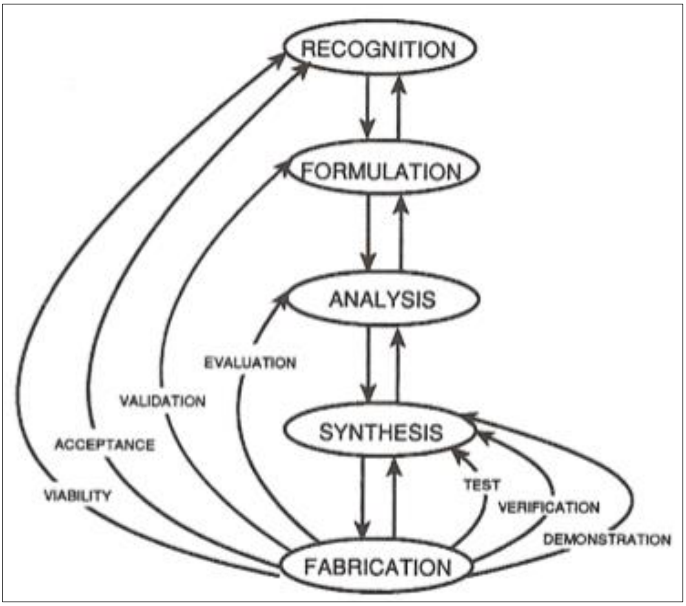
Not Quite Agile Methodology

"The basic assumption by organizations adopting agile is that there is no hope for improving the requirements process so they must jump into coding prototypes and getting user feedback quickly"

"This institutionalizes rework due to bad requirements and assumptions" (Tom King, Ravenflow).

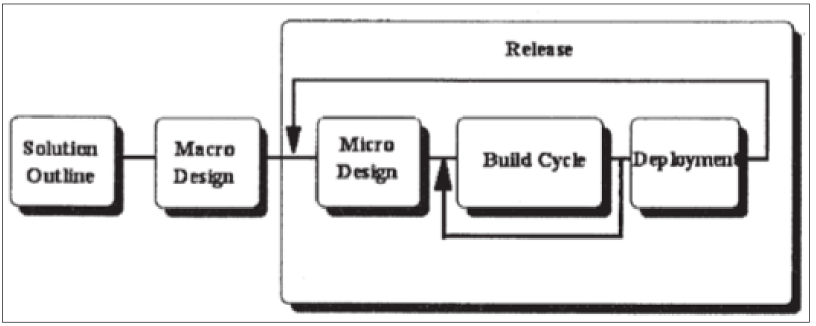
Hybrid Methodologies

Sequential methodologies are often presented as a "straw man" to be rejected, but their appropriateness depends on granularity -- every methodology has sequential characteristics Similarly, iterative methods are often presented as a radical departure from sequential methodologies, but every iterative methodology has some sequential characteristics when viewed from a "coarsed-grained" perspective (Design for Success).

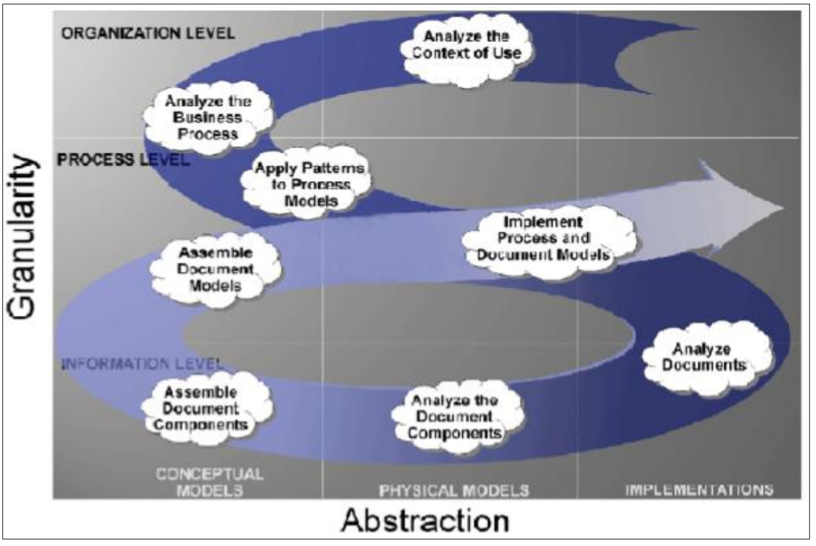


Artifact- or Work Product-Centered Methodologies

Artifact or work product-centered design methods specify activities, but put more emphasis on the artifacts or work products that result from them. These methodologies are less prescriptive about how the work is done, but might be very prescriptive about how it is documented. This approach is appropriate in complex projects with a distributed design team, and especially when designing in a "business ecosystem" of "service interfaces"



"Document Engineering" Methodology



Phase	Artifact
Analyzing the Context	UML use case diagrams
Analyzing/Designing Business Processes	Business Domain View Worksheet UML use case diagrams
Analyzing/Designing Business Collaborations	Business Process Area Worksheet UML activity diagrams
Analyzing/Designing Business Transactions	Business Transaction View Worksheet UML sequence diagrams
Applying Patterns to Business Processes	Document checklist

User-Centered Design at IBM Consulting

Why did IBM need a UCD methodology?

The IBM consulting approach uses "matrixed" project teams assembled from "best available" people wherever they are. But UCD consultants varied in their training, techniques, process, and deliverables. Difficult to write proposals, manage customer expectations, and perform effectively with such heterogeneity.

How was the methodology developed?

"A benchmark of known existing methodologies was performed, and best practices identified"

"Benchmarking" the practices in some industry is often done by a consulting firm or industry association because companies are not likely to tell competitors about their methods and capabilities. For a company as big as IBM, where there are lots of more or less competing consultants or consultant practice groups, internal benchmarking serves much the same purpose as industry benchmarking

How is it a "work-product" methodology?

The customer complaint of of "too many talkers and not enough do-ers" suggested an artifact- or work product-centered methodology that emphasizes the deliverables in an engagement, not the technique or process of delivery.

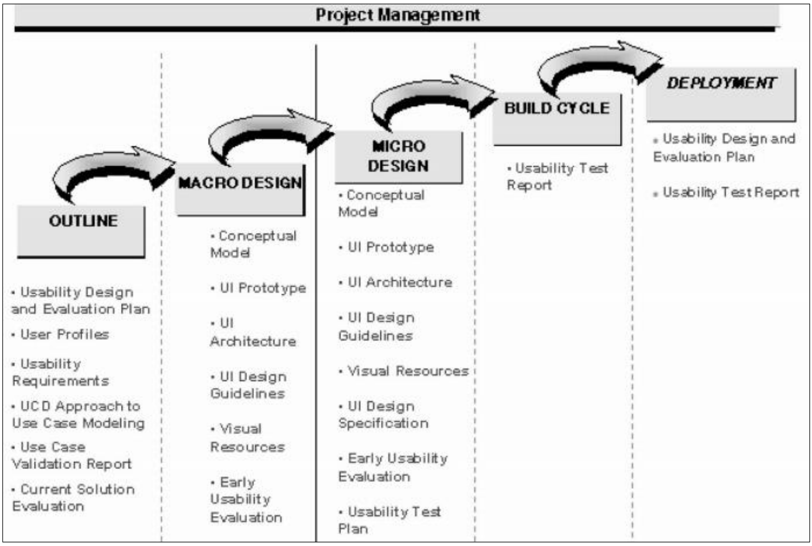
PUT ANOTHER WAY - get paid for results, not for effort

The goal that "no work product should ever be created from scratch" implies that all work products should follow detailed content specifications and that previous ones should be managed in a "knowledge base" to facilitate their reuse.

This is hard for technical and "organization culture" reasons

How is the methodology used in engagements?

All 15 of the UCD WPs aren't necessary or justified in every design context. For example, an incremental functional upgrade to a legacy system with a known and small set of users needs relatively few of them. There will be other recurring design contexts that will need different subset configurations of the WPs. The "Rapid Prototyping Engagement" is one of the most common


Project Management
OUTLINE
MACRO DESIGN
MICRO DESIGN
BUILD CYCLE
DEPLOYMENT
• Usability Design and Evaluation Plan
• User Profiles
• Usability Requirements
• UCD Approach to Use Case Modeling
• Use Case Validation Report
• Current Solution Evaluation
• Conceptual Model
• UI Prototype
• UI Architecture
• UI Design Guidelines
• Visual Resources
• Early Usability Evaluation
• Conceptual Model
• UI Prototype
• UI Architecture
• UI Design Guidelines
• Visual Resources
• UI Design Specification
• Early Usability Evaluation
• Usability Test Plan
• Usability Test Report
• Usability Design and Evaluation Plan
• Usability Test Report

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