Syllabus

	Engineering Design and Modelling	Course Type	LTP
Course Code:	**MEE2014**	**Credits**	**4**
Prerequisite:			

Course Objectives:

- To enhance the creative design knowledge and procedural plan.
- To understand the iterative engineering design process.
- To understand reliability, safety and regulation concerns in the product design.
- To develop written and oral communication skills.
- To develop professional behaviour, teamwork and leadership skills.
- To understand the importance of sustainable design solutions.

Course Outcomes (CO):

Students will be able to

CO1. Learn and apply the concept of engineering design and design thinking.

CO2. Understand the detailed design approaches knowledge in real-time and societal context

CO3. Understand the concept of sustainability and its implications.

CO4. Effectively articulate ideas, Work as a team, develop professional behaviour, teamwork and leadership skills.

CO5. Learn about Mechanical properties and modelling of various parts.

CO	Topics to be discussed	Hrs.
CO1	**Engineering Design Process and Design Thinking for Innovation** Design History; Dieter Rams Principles of Good Design; Overview of Engineering Design Process: Problem Formulation, Concept generation, Project Planning and Design Making; Human Centered Design (HCD); Design Thinking as Mindset, Process and Toolbox., Enhancing Design Thinking Through, Empathy, Interviewing, Questioning & Brainstorming Tools for Design Thinking: Mind Mapping, Innovation Flowchart - Question ladder – SCAMPER (for products) Journey Mapping,	**10**
CO2	**Engineering Design Approaches**: Professional and societal Context of Design; Different types of design – Conceptual, Embodiment designs and Detailed designs - Identification and Specifications, Standards and codes. Design Features - Design for Aesthetics, Production, Standards, Minimum risk, Ease of maintenance, Quality, Minimum cost and Optimum Design. Usability - User requirement; User experience; Usability testing; Customer Co-creation	**10**

CO3	**Sustainable Design and Communication** Concepts of sustainable development, Sustainable design principles - Design for Environment; Life Cycle Assessment; Models of sustainable design- Biomimicry, Eco Design, Recycling; Social Innovation.	**8**
CO4	**Metaphors and Prototyping** Metaphor method: Theory and methodology of concept generation, Blend method & Thematic Method. Articulating design ideas: Storytelling; Introduction to Sketching & Dynamic Diagrams; K Scripts, Introduction to Prototyping & Visualization Design Tools	**5**
CO5	**Materials and Modelling** Classification of engineering material, Composition of Cast iron and Carbon steels, Alloy steels their applications, definition of stress, strain and its types, Poisson's ratio, Stress-strain diagram of ductile and brittle materials, Hooks law and modulus of elasticity, Mechanical properties like strength, hardness, toughness, ductility, brittleness, malleability etc. of materials, modelling of objects (Shaft, water glass, cylinder (hollow/solid), convergent/divergent nozzle etc.)	**10**
	Guest Lecture on Contemporary Topics	**2**
		45

Text books:	
1.	Huge Jack, “Engineering Design, Planning, and Management” Academic Press, 2013.
2.	George E Dieter and Linda Schmidt “Engineering Design” Fifth edition, McGraw-Hill, 2012
Reference Books, Web reference:	
1.	Barry Hyman, “Fundamentals of Engineering Design”, 2nd edition, Pearson Education, 2003.
2.	Tracy Bhamra, Vicky Lofthouse, “Design for Sustainability: A Practical Approach”, Taylor and Francis, 2017.
3.	Walter Brenner, Falk Uebernickel, “Design Thinking for Innovation: Research and Practice”, Springer, 2016.
4	Jorge Paricio, Perspective sketching: Freehand and Digital Drawing techniques for Artists & Designers, Rockport Publishers
5	Dennis K. Lieu, Sheryl Sorby, Visualization, Modelling, and Graphics for Engineering Design, Delmar Cengage Learning, 2nd Edition
6	R.K. Bansal, Strength of Materials: Mechanics of Solids, 6th Edition, Laxmi Publication, 2018
7	Callister's, Materials Science and Engineering, 10th Edition, 2019
Recommendation by the Board of Studies on	

Proposed experiment List

1. Exposure and training of students in fundamental concepts of sketching based visual representations.
2. Hand sketching of general products (water bottle, mouse, laptop stand, mobile stand, travel bag, etc)
3. Hand sketching of products of your discipline.
4. Bio-inspired study (sketching of leaves, observation of bio-mimic structures etc).
5. The students need to develop product prototypes / models using thermocol, wood and Plaster of Paris etc.
6. Creative design on paper (Origami, Collage) with waste material.
7. Digital design of various products (poster, scientific illustration, mind maps, empathy map etc).
8. Design of any product using CAD software


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I'M DONE
WHAT NEXT?

What is design?

Design is a process to create something that has never been.

Module – 1
Introduction to Engineering design process

Engineering design is a systematic, intelligent process in which engineers generate, evaluate, and specify solutions for devices, systems, or processes whose form(s) and function(s) achieve clients' objectives and users' needs while satisfying a specified set of constraints.

In other words, engineering design is a thoughtful process for generating plans or schemes for devices, systems, or processes that attain given objectives while adhering to specified constraints.

Design objective: a feature or behavior that we wish the design to have or exhibit.

Design constraint: a limit or restriction on the features or behaviors of the design. A proposed design is unacceptable if these limits are violated.

Functions: things a designed device or system is supposed to do.

Means: a way or a method to make a function happen. For example, friction is a means of fulfilling a function of applying a braking force.

Form: the shape and structure of something as distinguished from its material. form is central to industrial design, a very important part of product design.

The Four C's of Design

- ✓ Creativity

Requires creation of something that has not existed before or has not existed in the designer's mind before.

- ❖ Choice

Requires making choices between many possible solutions at all levels, from basic concepts to the smallest detail of shape

- • Complexity

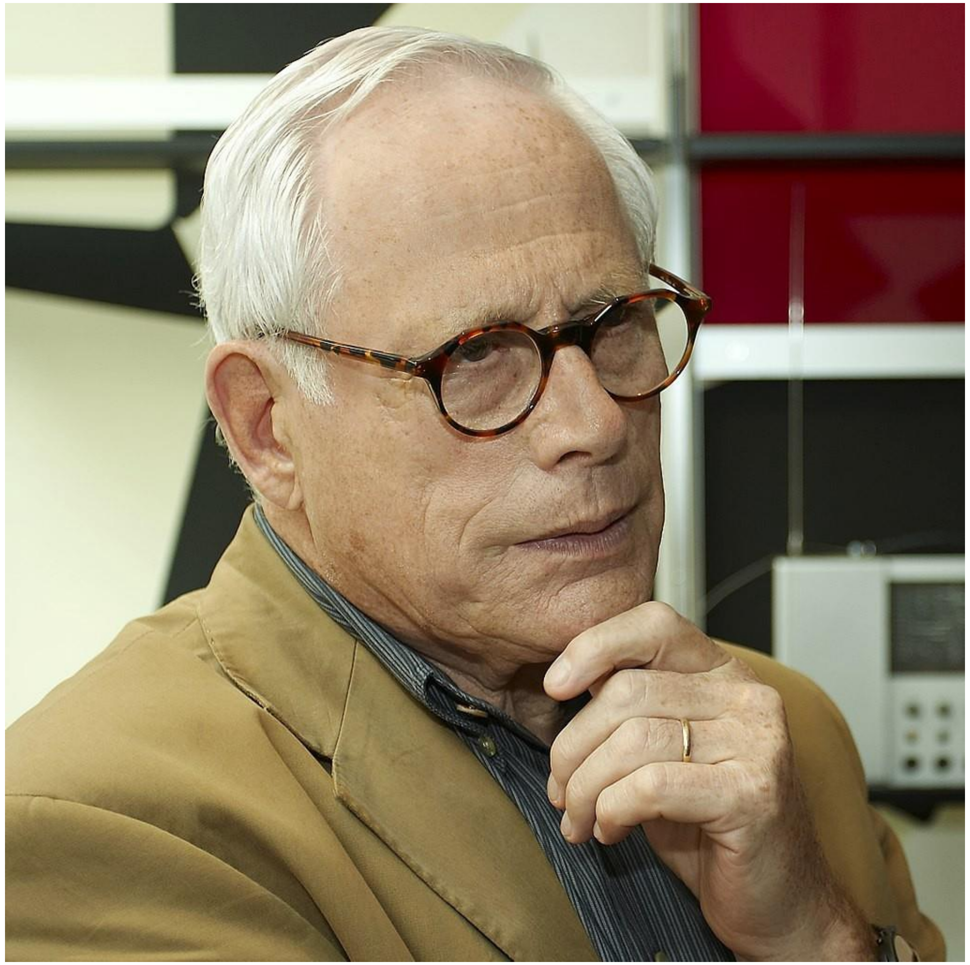
Requires decisions on many variables and parameters

- ❑ Compromise

Requires balancing multiple and sometimes conflicting requirements

Various types of Chair Designs

Design is really an act of communication, which means having a deep understanding of the person with whom the designer is communicating



Dieter Rams is a retired German industrial designer and academician.

- Dieter Rams, one of the most influential industrial designers of the last 50 years, has had a truly remarkable impact on the design industry and the overall concept of product design.
- Rams held a firm belief that good design can only come from understanding people. He urged everyone – not just designers – to take responsibility for the state of the world around them. Rams has been outspoken throughout his whole career about putting an end to wastefulness and drawing attention to the importance of preserving the earth's limited natural resources.
- Rams' design motto, was "Less, but better" has not only influenced his own professional works but also the work of some of the most well-recognized designers today, including Apple's SVP of Design, Jony Ive. In Apple's line of iPods, iPhones, iPads, and Macs, Ive's minimalist style closely mirrors the work and principles of Dieter Rams, sharing a similar, simplistic design methodology.
- "No part appeared to be either hidden or celebrated, just perfectly considered and completely appropriate in the hierarchy of the products details and features. At a glance, you knew exactly what it was and exactly how to use it." – Ive on Dieter Rams
- In the 1980's, Rams set out to create an overview of what defines good design. The beauty of these principles lies partly in the uniqueness of their composition, but also in the fact that they apply just as much to digital design as they do to industrial design. Let's take a look at these principles.

DIETER RAMS: TEN PRINCIPLES FOR GOOD DESIGN

1. Good design is innovative

"The possibilities for innovation are not, by any means, exhausted. Technological development is always offering new opportunities for innovative design. But innovative design always develops in tandem with innovative technology, and can never be an end in itself."

The takeaway:

This means that there is simply no excuse to not innovate. As digital and product designers we have constant access to developing technology. We need to use that technology to solve real-world problems, not just create gadgetry.

DIETER RAMS: TEN PRINCIPLES FOR GOOD DESIGN

2. Good design makes a product useful

“A product is bought to be used. It has to satisfy certain criteria, not only functional, but also psychological and aesthetic. Good design emphasizes the usefulness of a product whilst disregarding anything that could possibly detract from it.”

The takeaway:

A product should have a function, and a specific function. And that function includes objective and subjective outcomes (such as aesthetic and psychological satisfaction.) Anything that doesn’t directly or indirectly aid a user in attaining their goals through that functionality should be eliminated.

DIETER RAMS: TEN PRINCIPLES FOR GOOD DESIGN

3. Good design is aesthetic

“The aesthetic quality of a product is integral to its usefulness because products we use every day affect our person and our well-being. But only well-executed objects can be beautiful.”

The takeaway:

Let’s not kid ourselves: looks matter. Form should always follow function, but it shouldn’t be forgotten – it should follow. We should be concerned with the impact that aesthetics has on a user and delight them with the visual effect of your product.

DIETER RAMS: TEN PRINCIPLES FOR GOOD DESIGN

4. Good design makes a product understandable

"It clarifies the product's structure. Better still, it can make the product talk. At best, it is self-explanatory."

The takeaway:

This is paramount in product design. It is acceptable that there are products that are going to require documentation or at least basic explanatory content to use due to inherent complexity, but if a product requires inordinate instruction to be usable, something's wrong.

5. Good design is unobtrusive

"Products fulfilling a purpose are like tools. They are neither decorative objects nor works of art. Their design should therefore be both neutral and restrained, to leave room for the user's self-expression."

The takeaway:

Don't design a product around yourself. Further, don't design your product around a projection of what you expect or even want your user to be. Create a product that gets out of the way of the user and allows them to do what they want to do, while guiding them into a productive, and delightful method of doing it.

6. Good design is honest

"It does not make a product more innovative, powerful or valuable than it really is. It does not attempt to manipulate the consumer with promises that cannot be kept."

The takeaway:

The takeaway here is simple. We should be honest with our users about what we're delivering to them. However, we make a promise, whether that promise is presented through a visual affordance, iconography, or even through marketing, we need to make sure we follow through on it.

7. Good design is long-lasting

"It avoids being fashionable and therefore never appears antiquated. Unlike fashionable design, it lasts many years – even in today's throwaway society."

The takeaway:

Designing for the sake of fashion is a dangerous and generally unhelpful thing. What is fashionable today will at best be unfashionable tomorrow, and at worst, a piece of comedy in ten years.

DIETER RAMS: TEN PRINCIPLES FOR GOOD DESIGN

8. Good design is thorough down to the last detail

“Nothing must be arbitrary or left to chance. Care and accuracy in the design process show respect towards the user.”

The takeaway:

This is where good designers are separated from excellent designers. Every input, every image and block of text, every workflow should be thoroughly thought out to aid the user in their endeavors.

DIETER RAMS: TEN PRINCIPLES FOR GOOD DESIGN

9. Good design is environmentally friendly

"Design makes an important contribution to the preservation of the environment. It conserves resources and minimizes physical and visual pollution throughout the lifecycle of the product."

The takeaway:

In the digital realm, we don't have quite as much effect upon our physical environment as some other industries might. However, we still should be sensitive to our digital and logical environment. Ensuring that your product works with right-to-left languages, for instance, is often important for international products.

DIETER RAMS: TEN PRINCIPLES FOR GOOD DESIGN

10. Good design is as little design as possible

"Less, but better – because it concentrates on the essential aspects, and the products are not burdened with non-essentials.

Back to purity, back to simplicity."

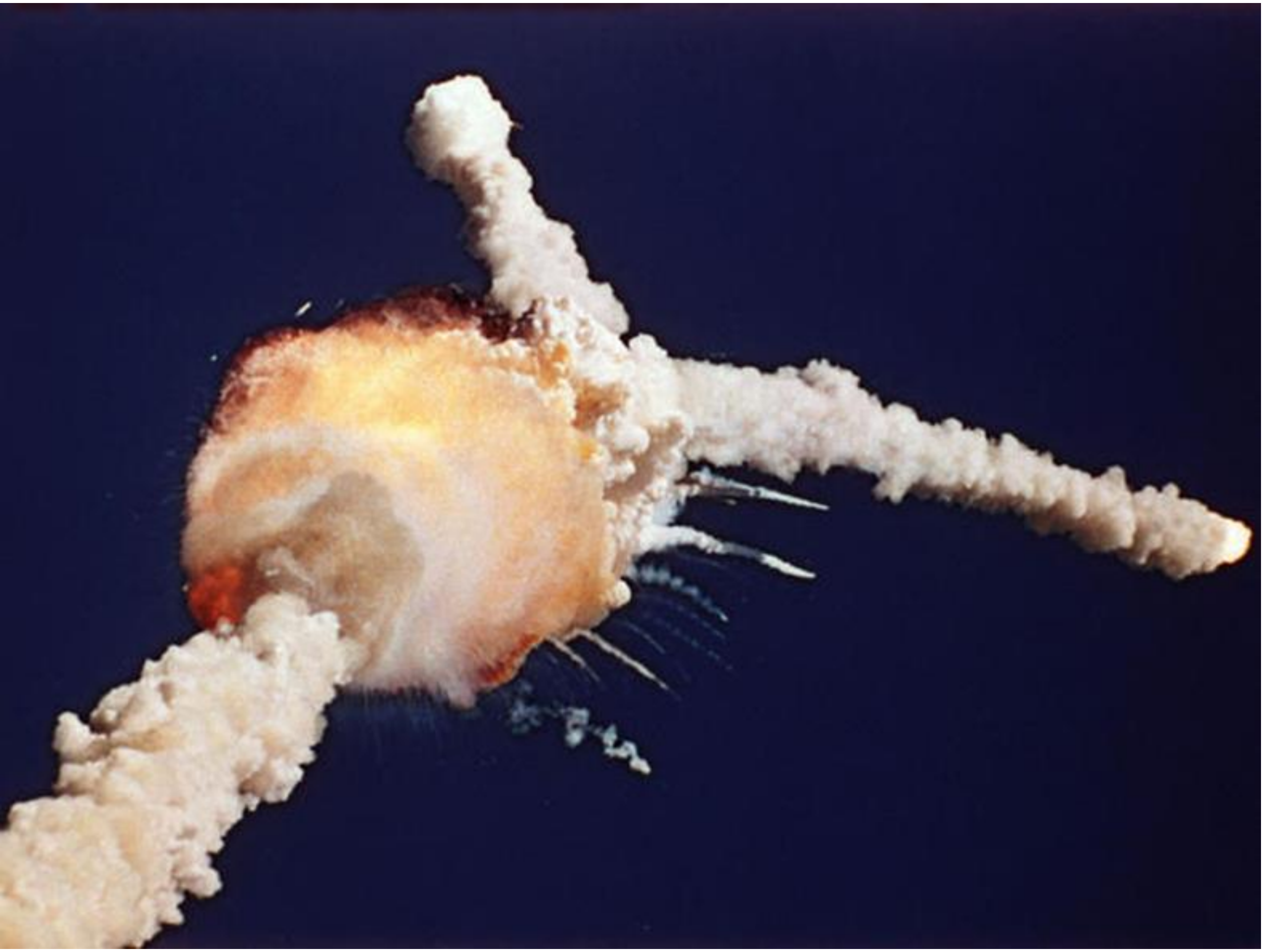
The takeaway:

This sums up a lot of design principles into one. Design should always be intentional, never just filigree. Anything that doesn't serve the user should be eliminated. (Again, however, design can serve a user either directly or indirectly – visual design can indirectly serve the user just as much as an excellent feature set can directly serve a user.

Summary

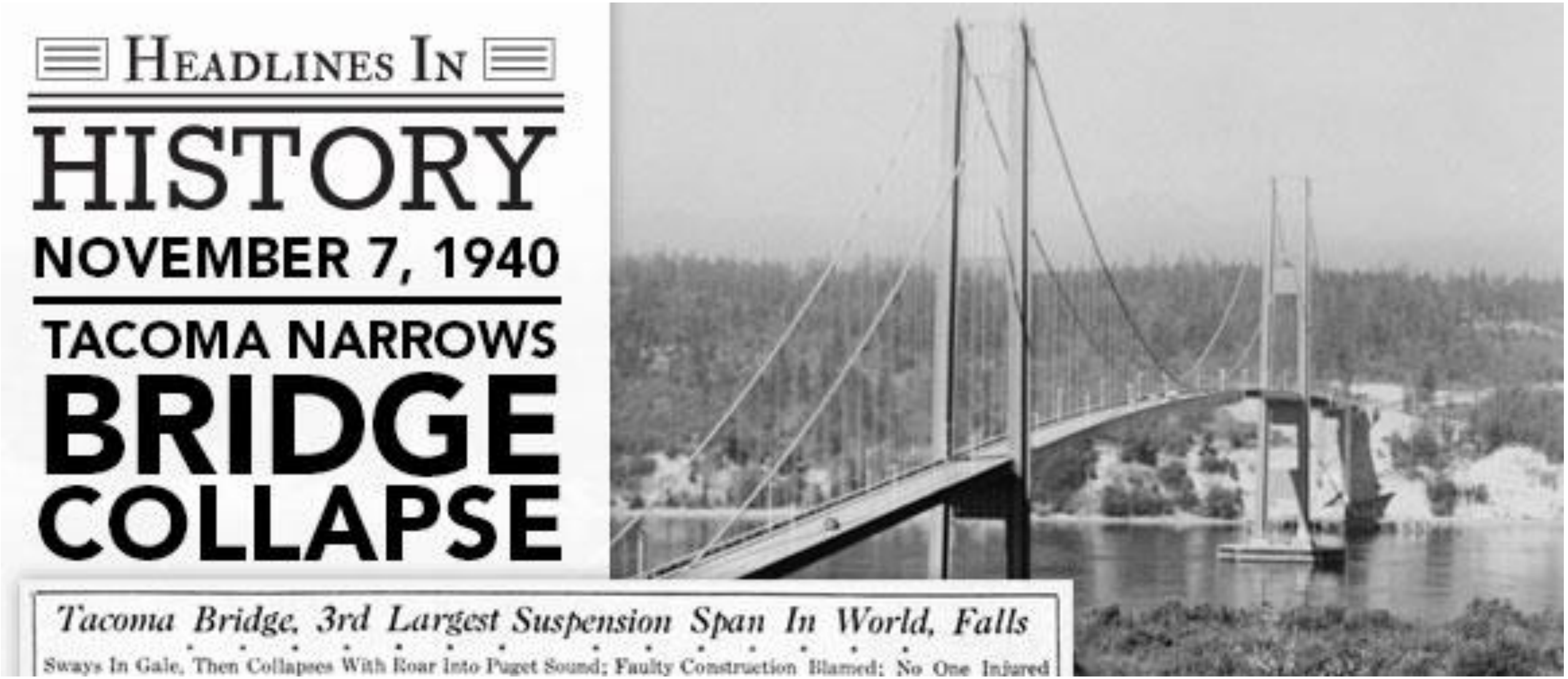
- Good design is innovative
- Good design makes a product useful
- Good design is aesthetic
- Good design makes a product understandable
- Good design is unobtrusive
- Good design is honest
- Good design is long-lasting
- Good design is thorough down to the last detail
- Good design is environment friendly
- Good design is as little design as possible

Challenger Disaster



January 28, 1986, when the Space Shuttle Challenger broke apart 73 seconds into its flight, killing all seven crew members aboard.

Tacoma Bridge Collapse



Bhopal Gas Tragedy

To avoid such types of failures we need a good design

Types of Designs

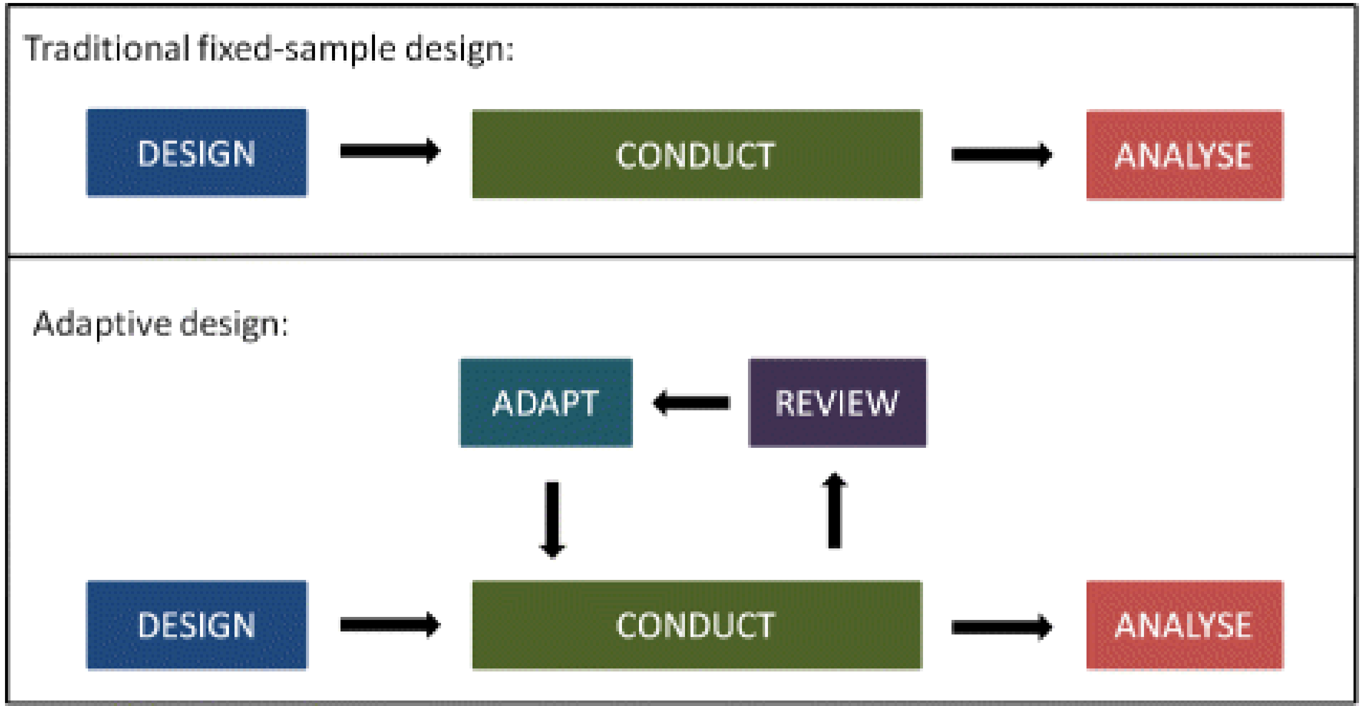
Engineering design can be undertaken for many different reasons, and it may take different forms.

Original design, also called innovative design. This form of design is at the top of the hierarchy. It employs an original, innovative concept to achieve a need. Sometimes, but rarely, the need itself may be original. A truly original design involves invention. Successful original designs occur rarely, but when they do occur they usually disrupt existing markets because they have in them the seeds of new technology of far-reaching consequences. The design of the microprocessor was one such original design.

Adaptive design

This form of design occurs when the design team adapts a known solution to satisfy a different need to produce a novel application.

For example: adapting the ink-jet printing concept to spray binder to hold particles in place in a rapid prototyping machine. Adaptive designs involve synthesis and are relatively common in design.

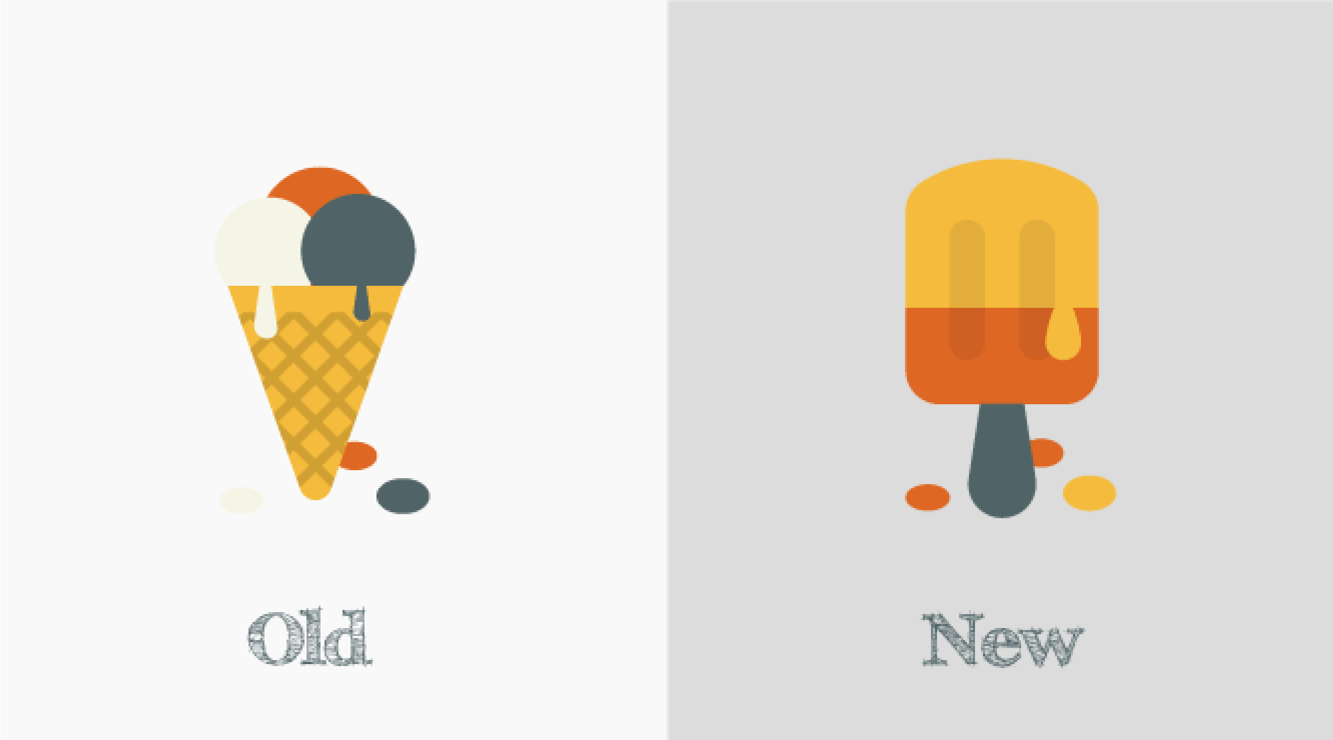


Redesign

Much more frequently, engineering design is employed to improve an existing design. The task may be to redesign a component in a product that is failing in service, or to redesign a component so as to reduce its cost of manufacture.

Often redesign is accomplished without any change in the working principle or concept of the original design.

Example: the shape may be changed to reduce a stress concentration, or a new material substituted to reduce weight or cost. When redesign is achieved by changing some of the design parameters, it is often called *variant design.*


Old
New

Selection design

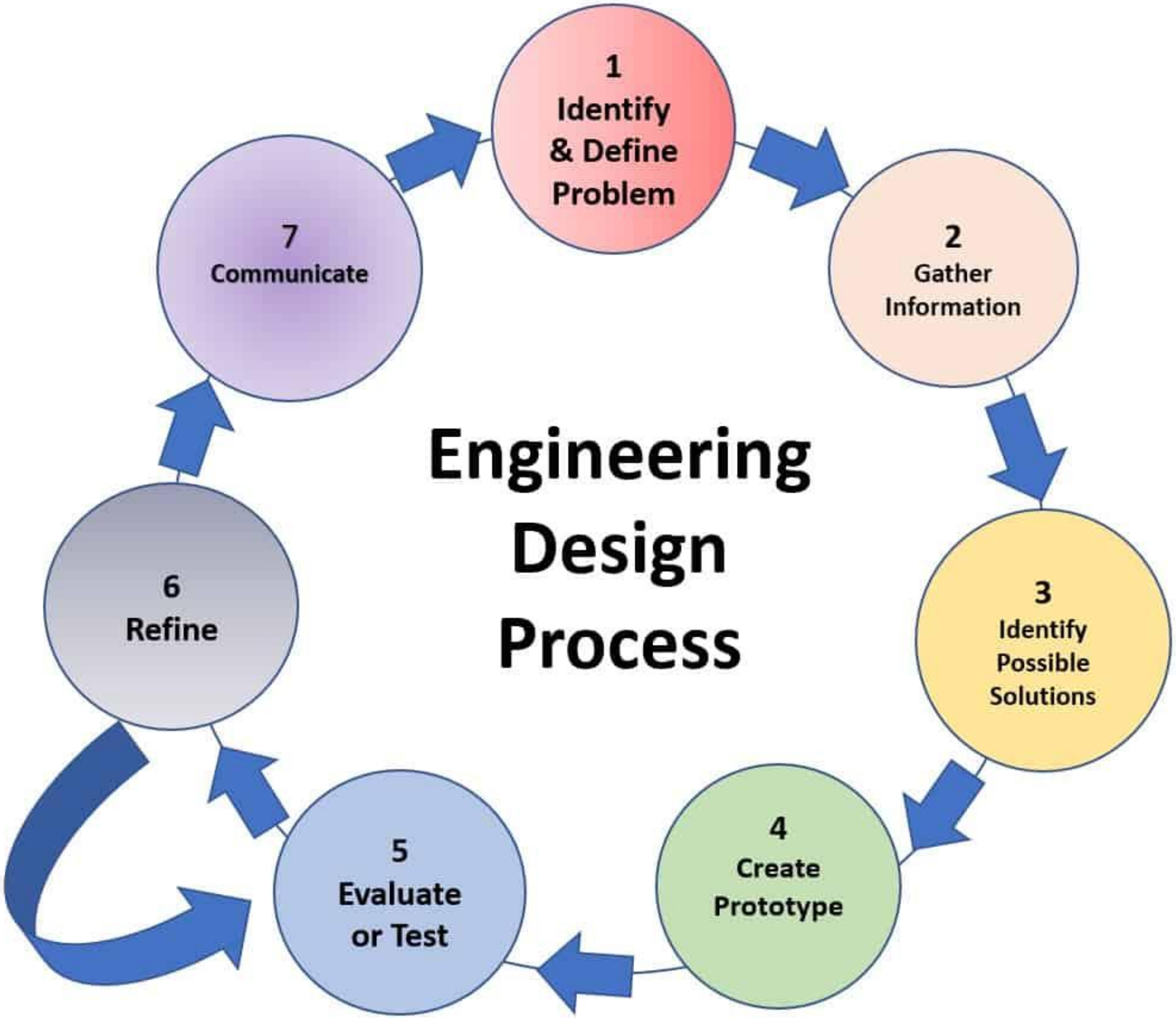
Most designs employ standard components such as bearings, small motors, or pumps that are supplied by vendors specializing in their manufacture and sale. Therefore, in this case the design task consists of selecting the components with the needed performance, quality, and cost from the catalogs of potential vendors.

Industrial design

This form of design deals with improving the appeal of a product to the human senses, especially its visual appeal. While this type of design is more artistic than engineering, it is a vital aspect of many kinds of design. Also encompassed by industrial design is a consideration of how the human user can best interface with the product.

THE ENGINEERING DESIGN PROCESS

https://www.youtube.com/watch?v=MAhpfFt_mWM


Engineering
Design
Process
1
Identify
& Define
Problem
2
Gather
Information
3
Identify
Possible
Solutions
4
Create
Prototype
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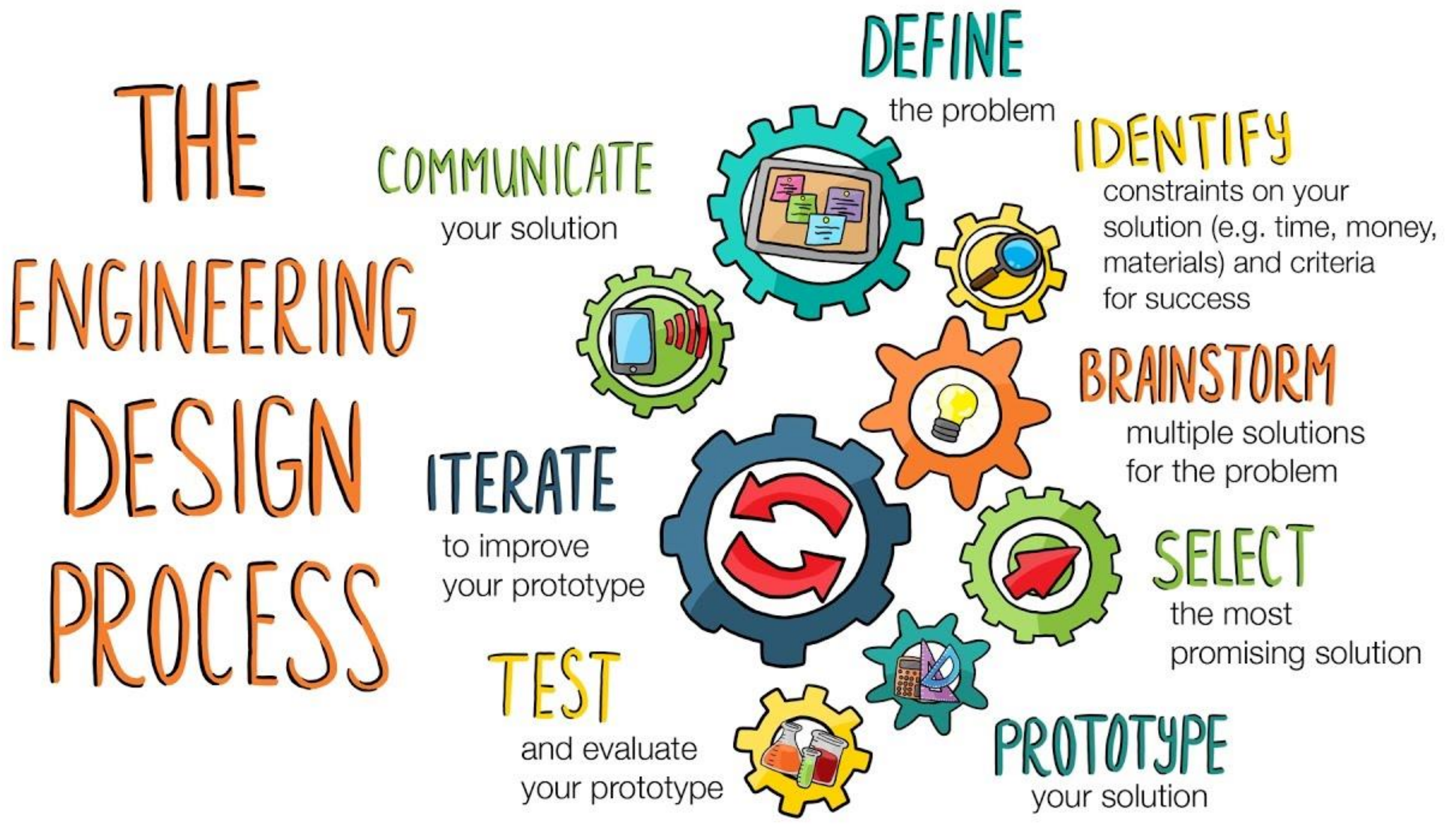
Evaluate
or Test
6
Refine
7
Communicate


THE ENGINEERING DESIGN PROCESS
DEFINE
the problem
IDENTIFY
constraints on your solution (e.g. time, money, materials) and criteria for success
BRAINSTORM
multiple solutions for the problem
SELECT
the most promising solution
PROTOTYPE
your solution
TEST
and evaluate your prototype
ITERATE
to improve your prototype
COMMUNICATE
your solution

PROBLEM

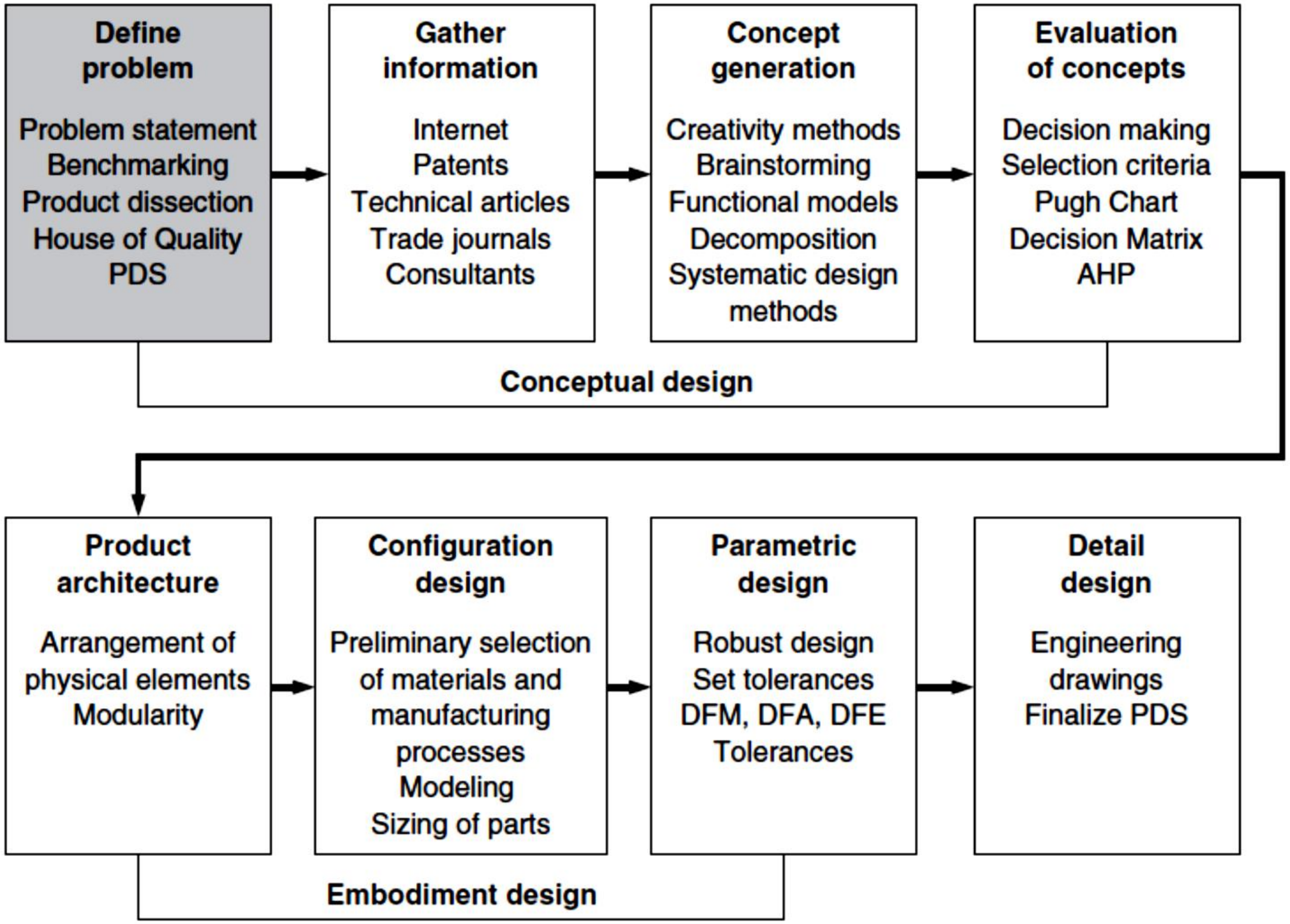


Figure: The product development process showing problem definition as the start of the conceptual design process.

Problem Formulation

Understanding any problem thoroughly is crucial to reaching an outstanding solution. This axiom holds for all kinds of problem solving, whether it be math problems, production problems, or design problems.

In product design the ultimate test of a solution is meeting *management's goal* in the marketplace, so it is vital to work hard to understand and provide what it is that the *customer wants*.

This topic emphasizes the *customer satisfaction* aspect of *problem definition*, an approach not always taken in engineering design. This view turns the design problem definition process into the identification of what outcome the customer or end user of the product wants to achieve.

Problem Formulation

1. IDENTIFYING CUSTOMER NEEDS

Increasing worldwide competitiveness creates a need for greater focus on the customer's wishes. Engineers and businesspeople are seeking answers to such questions as:

Who are my customers?
What does the customer want?
How can the product satisfy the customer while generating a profit?

(i) Preliminary Research on Customers Needs

The initial work may be done by a marketing department specialist or a team made up of marketing and design professionals.

Problem Formulation

(ii)Gathering Information from Customers

Interviews with customers - Active marketing and sales forces should be continuously meeting with current and potential customers. Some corporations have account teams whose responsibility is to visit key customer accounts to probe for problem areas and to cultivate and maintain friendly contact.

Focus groups - A focus group is a moderated discussion with 6 to 12 customers or targeted customers of a product. The moderator is a facilitator who uses prepared questions to guide the discussion about the merits and disadvantages of the product.

Customer complaints - A sure way to learn about needs for product improvement is from customer complaints. These may be recorded by communications (by telephone, letter, or email) to a customer information department, service center or warranty department, or a return center at a larger retail outlet. Third party Internet websites can be another source of customer input on customer satisfaction with a product.

Problem Formulation

Warranty data - Product service centers and warranty departments are a rich and important source of data on the quality of an existing product. Statistics on warranty claims can pinpoint design defects.

Customer surveys - A written questionnaire is best used for gaining opinions about the redesign of existing products or new products that are well understood by the public. Other common reasons for conducting a survey are to identify or prioritize problems and to assess whether an implemented solution to a problem was successful. A survey can be done by mail, e-mail, telephone, or in person

Problem Formulation

2. CUSTOMER REQUIREMENTS

Information gathered from customers and research on products from market literature and experimentation contributes to creating a ranked listing of customer needs and wants. These are the needs that form the end user's opinion about the quality of a product.

Garvin identified the eight basic dimensions of quality for a manufactured product. These have become a standard list that design teams use as a guide for completeness of customer requirement data gathered in the PDP.

Problem Formulation

1. Performance: The primary operating characteristics of a product. This dimension of quality can be expressed in measurable quantities, and therefore can be ranked objectively.
2. Features: Those characteristics that supplement a product's basic functions. Features are frequently used to customize or personalize a product to the customer's taste.
3. Reliability: The probability of a product failing or malfunctioning within a specified time period.
4. Durability: A measure of the amount of use one gets from a product before it breaks down and replacement is preferable to continued repair. Durability is a measure of product life. Durability and reliability are closely related.
5. Serviceability: Ease and time to repair after breakdown. Other issues are courtesy and competence of repair personnel and cost and ease of repair.

Problem Formulation

6. Conformance: The degree to which a product's design and operating characteristics meet both customer expectations and established standards. These standards include industry standards and safety and environmental standards. The dimensions of performance, features, and conformance are interrelated. When competing products have essentially the same performance and many of the same features, customers will tend to expect that all producers of the product will have the same quality dimensions. In other words, customer expectations set the baseline for the product's conformance.

7. Aesthetics: How a product looks, feels, sounds, tastes, and smells. The customer response in this dimension is a matter of personal judgment and individual preference. This area of design is chiefly the domain of the industrial designer, *who is more an artist than an engineer. An important technical issue that affects aesthetics is ergonomics, how well the design fits the human user.*

8. Perceived quality: This dimension generally is associated with *reputation.* Advertising helps to develop this dimension of quality, but it is basically the quality of similar products previously produced by the manufacturer that influences reputation.

Problem Formulation

Classifying Customer Requirements

Expecter’s: These are the basic attributes that one would expect to see in the product, i.e., standard features. Expecter’s are frequently easy to measure and are used often in benchmarking.

Spoken’s: These are the specific features that customers say they want in the product. Because the customer defines the product in terms of these attributes, the designer must be willing to provide them to satisfy the customer.

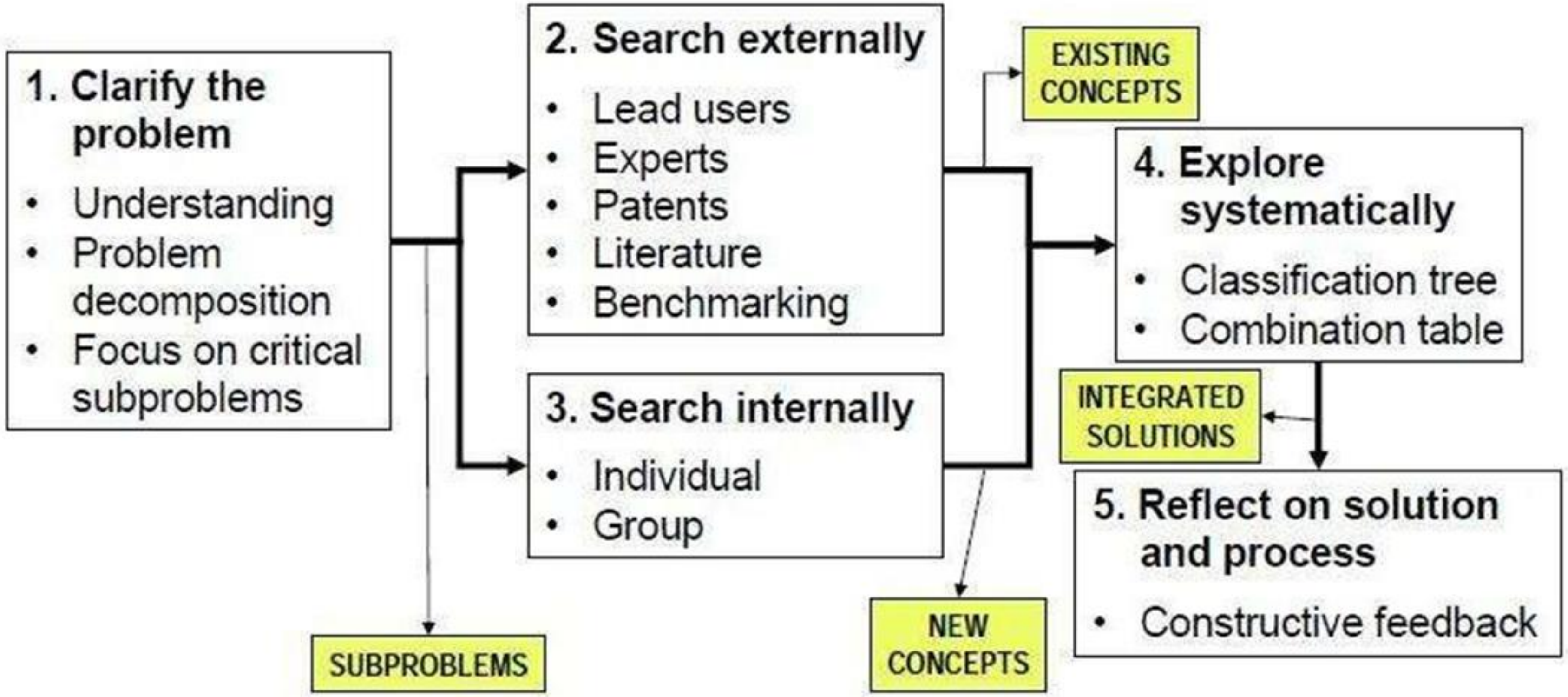
Unspoken’s: These are product attributes the customer does not generally talk about, but they remain important to him or her. They cannot be ignored. They may be attributes the customer simply forgot to mention or was unwilling to talk about or simply does not realize he or she wants. It takes great skill on the part of the design team to identify the unspoken requirements.

Exciters: Often called delighters, these are product features that make the product unique and distinguish it from the competition. Note that the absence of an exciter will not make customers unhappy, since they do not know what is missing.

‘If you have an apple and I have an apple and we exchange these apples then you and I will still have an apple.
But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas.’

George Bernard Shaw, 1856–1950

Concept Generation Process

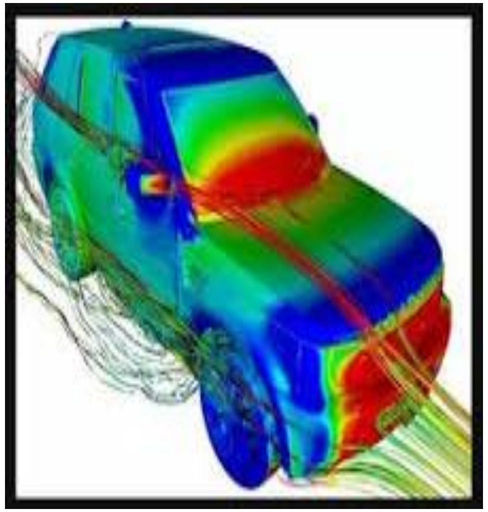


Brainstorming

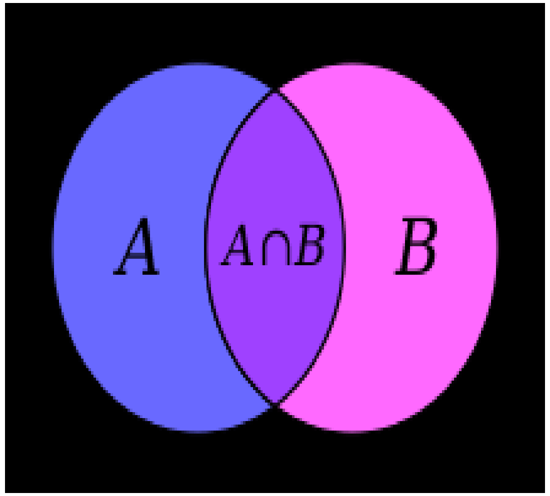
Prototyping

Pilot testing

Major concept generation techniques

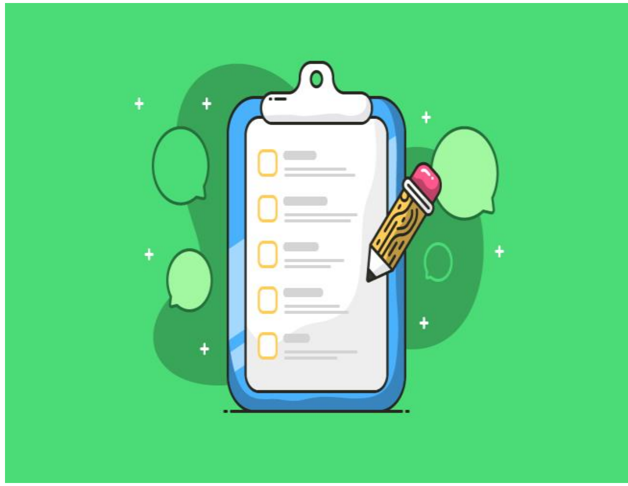


Simulation



Axiomatic

Ideation



Survey

Project Planning and Management

Project Planning and Management

The project manager is responsible for creating, tracking, and revising the plan. However, the process of planning should include multiple groups and people, typically called stakeholders, or sometimes the audience.

The planning process has multiple steps including

(1) Breaking the project into a set of tasks,

(2) Developing a list of approvals and milestones,

(3) Itemizing required resources,

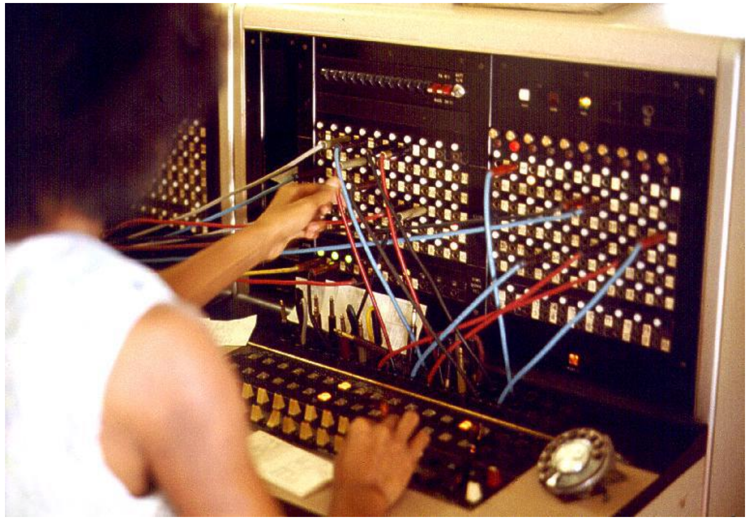
(4) Checking the plan for consistency.

The plan often includes a schedule for tasks and time, a budget for money, and a communication list.

Project Planning and Management

‘Imagination is more important than knowledge.
Knowledge is limited. Imagination encircles the world.’

Albert Einstein, 1929



Technology Centred Design

Business Centred Design

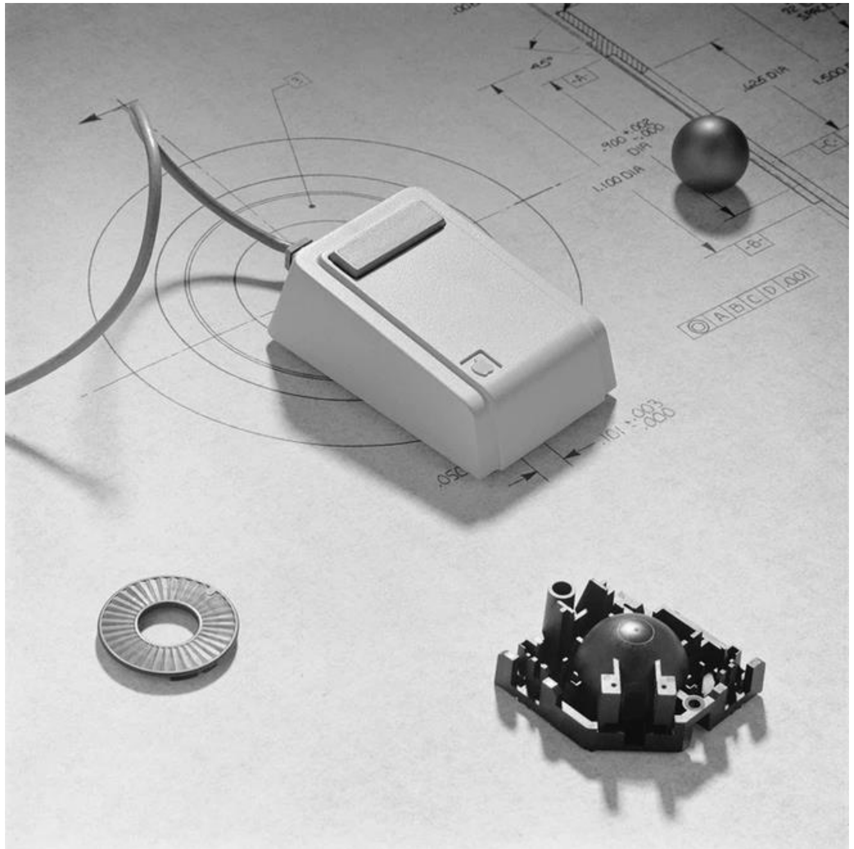
Designer Centred Design

When you understand the people you're trying to reach—and then design from their perspective—not only will you arrive at unexpected answers, but you'll come up with ideas that they'll embrace.

Human Centered Design (HCD)

https://www.youtube.com/watch?v=musmgKEPY2o

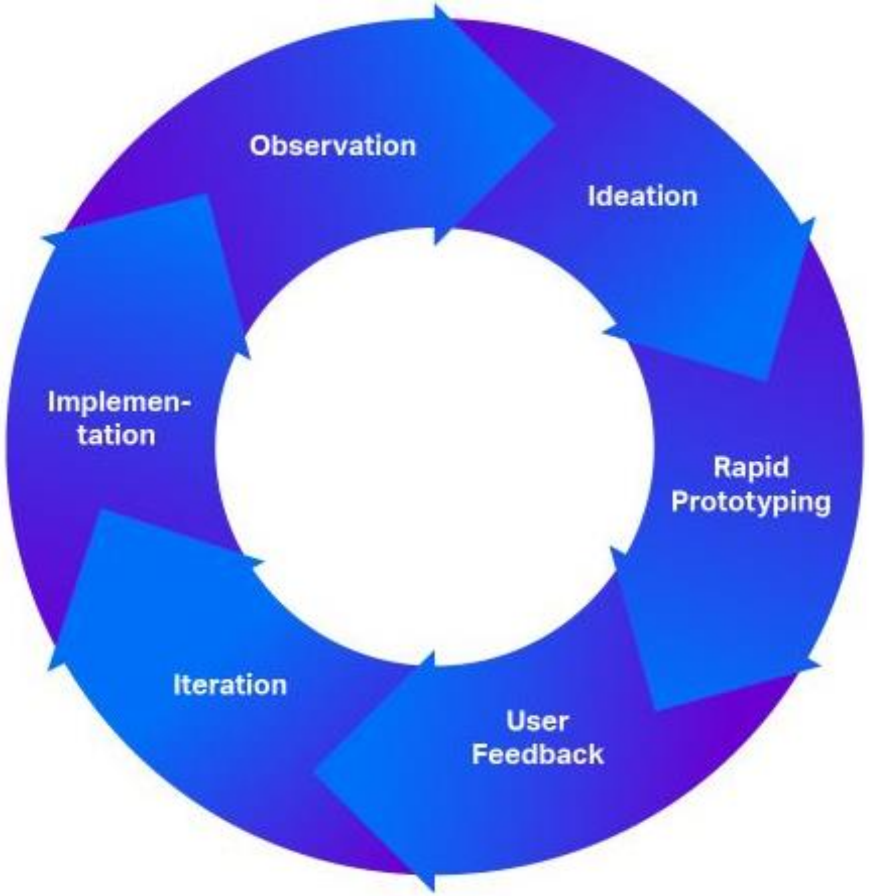
Human Centered Design (HCD)



IDEO designs the original mouse for Apple

Human Centered Design (HCD)

Human centered design is a creative approach to problem-solving that starts with people and ends with innovative solutions that are tailor-made to suit their needs.



IRUIIO

Human Centered Design (HCD)

Phase 1: Observation

The first phase is all about observing the end-user, learning, and being open to creative possibilities. Your goal is to understand the people you're designing for. Identify patterns of behavior, pain points, and places where users have a difficult time doing something—these all lend to tremendous opportunity. If you can, put yourself in their situation so you can see what their experience is, and feel what they feel.

Phase 2: Ideation

In this phase, you start brainstorming ideas with your team based on what you learned from your observations and experiences in Phase 1. Your goal is to come up with as many ideas as you can. As you're coming up with ideas, stay focused on the needs and desires of the people you're designing for. If you do this, your group's ideas will eventually evolve into the right solution.

Human Centered Design (HCD)

Phase 3: Rapid prototyping

In this phase, you're going to quickly build a simple prototype of your idea. This makes it tangible and gives you something to test with the end-user. Don't try to build a fancy high-fidelity prototype right now. Its advisable to create simple prototypes made out of cardboard.

Ask yourself this: What can I spend the minimum amount of time building that will allow me to get user feedback as quickly as possible? The purpose of this phase isn't to create the perfect solution; it's to make sure your solution is on target.

Phase 4: User feedback

Get your simple prototype into the hands of the people you're designing for. This is the most critical phase of the human centered design process. Without input from your end-user, you won't know if your solution is on target or not, and you won't know how to evolve your design.

Human Centered Design (HCD)

Phase 5: Iteration

Once you get feedback from your users, use that information to fuel the changes to your design. *Keep iterating, testing, and integrating user feedback until you've fine-tuned your solution.* This may take a few rounds, but don't get discouraged. With each iteration, you'll learn something new. Once you've got your solution to a point where it's ready to be used, it's time to move on to the next and final phase.

Phase 6: Implementation

Now that you've validated the usefulness of your solution with the end-user and gotten your design just right, it's time to get your idea out into the world. If you're designing software products, apps, or websites, go back to Phase 1 and repeat this process. With each new update that you implement, continue to observe your users, design for them, and use their feedback to direct your future solutions.


Thank
YOU
!