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1. Introduction to Product Design

1.0 WHAT IS DESIGN?

Design is the creation of the objects or system or services that people use. The objects can range from dresses, buildings, automobiles, computers, advertisement material, retailing, banking, transportation, and healthcare.

Design in defined in several ways as per the application in different fields. Some of the definitions are as follow:

- "Design is what links creativity and innovation. It shapes ideas to become practical and attractive propositions for users or customers.
  Design may be described as creativity deployed to a specific end."

  -Sir George Cox
- Design is a plan to make something new for people, that they perceive as beneficial
  (https://www.kooslooijesteijn.net/blog/what-is-design)
- It's not just what it looks like and feels like. Design is how it works.
  (https://www.nytimes.com/2003/11/30/magazine/the-guts-of-a-new machine.html)
- The art or process of deciding how something will look, work.
  (https://www.oxfordlearnersdictionaries.com/definition/english/design_1)
- The way in which something is planned and made
  (https://dictionary.cambridge.org/dictionary/english/design)
- Design is a visual look or a shape given to a certain object, in order to make it more attractive, make it more comfortable or to improve another characteristic.
  (hitps://simple.wikipedia.org/wiki/Design)

- A design is a plan or specification for the construction of an object or system or for the implementation of an activity or process, or the result of that plan or specification in the form of a prototype, product or process.
  (https://en.wikipedia.org/wiki/Design)
- Design is the process of devising a system, component, or process to meet desired needs.
  (http://www.me.unlv.edu/Undergraduate/coursenotes/meg497/ABETdefinition.htm)
- Design is the process and art of planning and making detailed drawings of something
  (https://www.collinsdictionary.com/dictionary/english/design)
- The process of deciding how something will be made, including how it will work and what it will look like.
  (https://www.macmillandictionary.com/dictionary/british/design_1)
- A specification of an object, manifested by some agent, intended to accomplish goals, in a particular environment, using a set of primitive components, satisfying a set of requirements, subject to some constraints.
  (https://www.fastcompany.com/90184338/is-there-a-scientific-definition-of-design)

In very general terms, design is the realisation of a concept, idea, theory, or imagination into a sketch, drawing, plan, specification, model, and so on that ultimately allows a series objectives to be realized.

In terms of construction, design is the process of creating a solution to a project brief and then preparing instructions allowing that solution to be constructed.

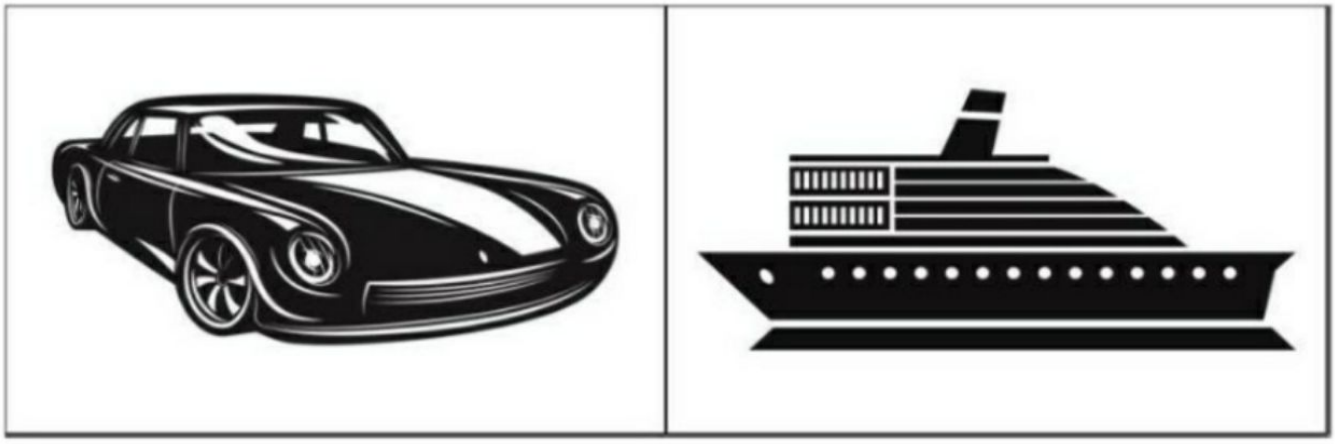
The design process must rationalise different and sometimes contradictory requirements such as budget, structure, regulations, climate, weather, security, privacy, to create a unified whole. This can be overlaid by the adoption of design

principles such as; balance, unity, movement, emphasis, contrast, space, alignment, and so on.

Examples of Design

Fig. 1.1 Old and New bag for carrying groceries

Fig. 1.2 Design puts the world in your hands **Fig. 1.3 Design helps us play games**



(a) Mobility on surface **(b) Mobility in water**

(c) Mobility in air

Fig. 1.3 Design helps us move

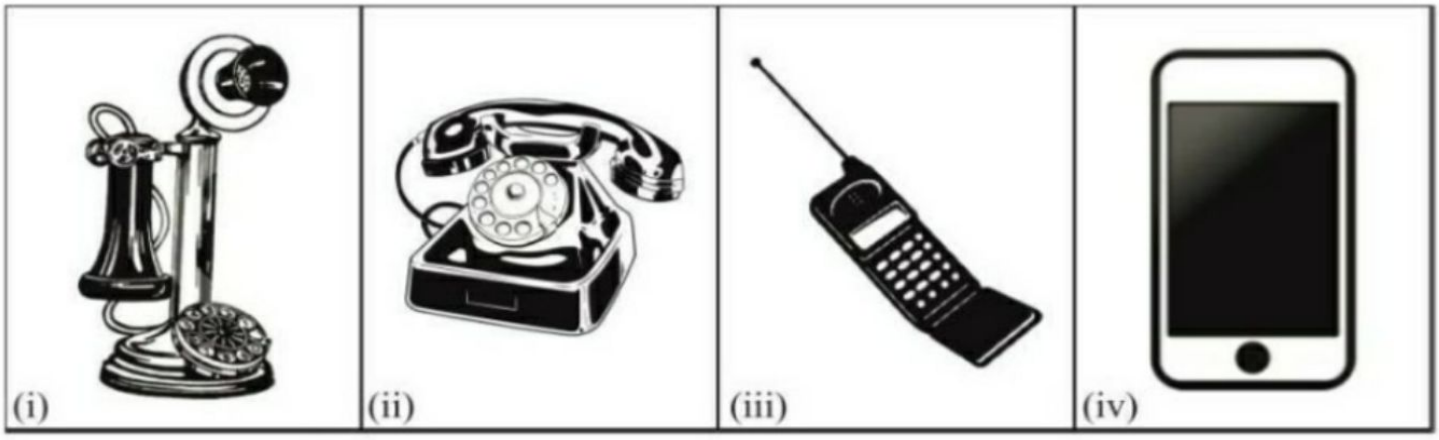


Fig. 1.4 Design can be incremental or radical

1.1 NEW PRODUCT OR SERVICE

- I Create
- I Take Risks
- I Live my Passion
- I am an Entrepreneur

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A few straight situations to be addressed about a new product or a service are:

i) Is there a need or desire for the product?

ii) What is the trigger? What is the need? Is this a new product you intend to invent or is it a breakthrough idea to revolutionise the current marketplace?

iii) Did you identify any pain area which you meant to address?

iv) Can the customer buy it?

v) Why should anybody buy your idea or your product or service? What experience you would provide which is different from the way need is met currently? Is it affordable? Is it a mass market product or are you looking at a niche market?

vi) Is the size of the potential market adequate? What is the current market size?

vii) Who are the major players? What is that they are doing right now?

viii) How do you intend to make inroads? How do you make people aware of your product or services?

ix) Is the opportunity big enough or is it just fishing in the dry pond?

x) Could it be created with available technology and materials, or would it require a breakthrough of some sort?

xi) What is your big idea? Is it revolutionary? Will it make people sit and take notice?

xii) Will the final product or service satisfy the market?

xiii) How do you ensure that the product or service you intended actually serving or doing what it was meant to do?

xiv) What are the checks? What is the feedback mechanism?

xv) How are you simplifying? One of my mentors used to tell me, bring things down to the lowest denominator and they become simple automatically, very simple, however very profound!

1.2 DESIGN METHODOLOGY

Design Methodology is a prerequisite for flexible and continuous design process using product models stored in a computer or library documentation. A design methodology, therefore must:

i) allow a problem-directed approach; i.e. it must be applicable to every type of design activity, no matter which specialist field it involves

ii) foster inventiveness and understanding; i.e. facilitate the search for optimum solutions

iii) be compatible with the concepts, methods and findings of other disciplines

iv) not rely on finding solutions by chance

v) facilitate the application of known solutions to related tasks

vi) be compatible with electronic data processing

vii) be easily taught and learned

viii) reflect the findings of cognitive psychology and modern management science; i.e. reduce workload, save time, prevent human error, and help to maintain active interest

ix) ease the planning and management of teamwork in an integrated and interdisciplinary product development process

x) provide guidance for leaders of product development teams.

1.3 PROXIMITY DESIGN

The principle of proximity is simply the process of ensuring related design elements are placed together. Any unrelated items, should be spaced apart. Close proximity indicates that items are connected or have a relationship to each other and become one visual unit which helps to organise or give structure to a layout. It is very simple that

something you see every day. On your web page or your business card, related information is placed closely together and it forms a visual unit. The following example explains how proximity design is used in rural development in Mynanmar.

Proximity Design uses a design approach to improve the incomes and well-being of rural families in Myanmar. They employ professional designers, engineers and ethnographers to discover unmet needs and opportunities for new products and services. The organisation operates a local design lab in Myanmar where its product designers create and test multiple prototypes with the goal of developing products that i) provide value to rural customers by increasing household productivity and incomes; and, ii) are affordable for families earning $2 per day or less. Products reach villages nationwide through a distribution network of private agro-dealers and independent village agents. After-sales support and repair services are also offered to user households. Proximity conducts annual surveys to measure customer satisfaction and to document improvements in farm family incomes.

Proximity Design's portfolio of products and services are marketed under the *Yetagon* brand in Myanmar and include:

i) *Foot-operated irrigation pumps* that draw water from wells, streams or ponds. Approximate capacity is 4,500 liters per hour.

ii) *Gravity-fed drip irrigation systems* consisting of low-cost extruded plastic tape and small micro-tubes connected to an elevated water storage tank. A single drip system is designed to irrigate a 1/8 acre plot but can be linked to other systems to cover an acre.

iii) *Portable water storage tanks* made from plastic tarpaulin material, commonly used as elevated tanks as part of Proximity's gravity-fed drip irrigation systems. These tanks come in three different sizes – 100, 150 and 250 gallons.

iv) *Farm advisory services* featuring training in selected low-cost, simple agricultural practices that increase yields and protect farmers against losses caused by pests, diseases and overuse of pesticides.

Proximity Designs also designs and implements humanitarian village stimulus programs that build community infrastructure while offering wage employment to economically stressed villages. Since 2008, more than 1,000 village projects have been completed in the cyclone-hit Irrawaddy Delta and the drought-prone central Dry Zone region of Myanmar.

Proximity Designs engages in field analysis of rural economic conditions and produces reports of findings. Proximity Designs Is Making Money Off The Poor By Designing Products They Need. Poor people have some cash to spend, they just need to be careful how they use it. But they're a huge market waiting to be tapped, if companies can make things they're willing to buy.

1.4 WHAT IS DESIGN THINKING?

Design thinking refers to the cognitive, strategic and practical processes by which design concepts (proposals for new products, buildings, machines, etc.) are developed. Many of the key concepts and aspects of design thinking have been identified through studies, across different design domains, of design cognition and design activity in both laboratory and natural contexts.

1.4.1 How to Use Design Thinking in Everyday Life?

Design thinking can innovate solutions for many everyday problems in life. Five ways to use Design Thinking in daily routine are:

i) Visualize the problem. Whether solving critical global problems or tackling micro-level projects, visualization reveals key themes and patterns.

ii) Challenge common assumptions. ...

iii) Reverse Thinking. ...

iv) Empathize with audience. ...

v) Embrace risk and failure.

The following are the best tools at the Design Thinking stage

i) Empathize: Typeform, Zoom, Creator

ii) Define: Smaply, Userforge, MakeMyPersona.

iii) Ideate: SessionLab, Stormboard, IdeaFlip.

iv) Prototype: Boords, Mockingbird, POP.

v) Test: UserTesting, HotJar, PingPong.

vi) For the complete process: Sprintbase, InVision, Mural, Miro.

1.4.2 The Design Thinking Mindset

Design is not so much as a physical process but as a way of thinking. Design Thinking is firmly based on generating a holistic and empathic understanding of the problems that people face, and that involves ambiguous or inherently subjective concepts such as emotions, needs, motivations, and drivers of behaviours. This contrasts drastically with a scientific approach that relies on quantitative research to understand the user's needs. Design Thinking is a third way: "Nobody wants to run a business based on feeling, intuition and inspiration, but an overreliance on the rational and the analytical can be just as dangerous. The integrated approach at the core of the design process suggests a third way."

-Tim Brown

It can be understood that Design Thinking combines two very different ways of thinking:

i. Analytical thinking

ii. Creative thinking

The design way of thinking leans on a set of principles that guides the ethic of the Design Thinking process. The first principle demands that the design thinker question everything: the problem, the assumptions and implications in order to get to the root causes of the initial problem. Another main principle is about placing the people,

designers are designing for at the center of the design process. This links to empathy as a foundation of Design Thinking. The third principle is about communicating visually: visualizing information, in order to make our personal mental models or representations of the external reality, visible to the outside world, and by that, to the team. Then, the forth core principle is about collaboration and co-creation. Design Thinking is collaborative and inclusive as it aims to include stakeholders in the design process but also to build teams with people from varied backgrounds and viewpoints in order to enable breakthrough insights and solutions. Finally, another important principle is iteration, as previously mentioned. The idea behind is to release solutions quickly in order to gather continuous feedback. These principles are just the main ones among other rules. They all contribute to providing guidelines in the application of the process such as creating a more democratic approach to decision-making, or a more experimental approach to the innovative process.

1.4.3 Design Thinking for Mobility

As already discussed design thinking is a systematic approach to problem solving. It starts with customers and the ability to create a better future for them. It acknowledges that we probably won't get that right the first time. Design 'insists' that we prepare ourselves to iterate our way to a solution.

With its focus on customers, useful research, testing, and de-risking activities, design thinking is a good match for communities looking to solve complex customer needs. The process, tips, and tools offered through this website will support communities in pursuing a customer-centered approach to improving or innovating community transportation offerings.

The nature of mobility management makes professionals in the field experts at working with customers to reach the "right fit" solution to maximize communities' access to resources and address their needs. Because transportation is such a valuable link to economic development and healthy communities, it's vital to tailor mobility options to the ever-evolving travel needs of community members.

There are a variety of tools to facilitate this work, and one that merits particular attention is design thinking. Using a customer-focused approach, this method leverages the skills, experience, and networks of local partners through ethnographic research to lower the risk of testing new ideas in solving complex mobility needs, and increasing the odds of developing and sustaining successful, responsive transportation services for a diverse set of community members. With an open and flexible mindset, design thinking is a valuable tool that can bring out ideas that practitioners may not have otherwise thought of as potential solutions

1.4.4 Design Thinking for Social Innovation

Sternin's preferred approach to social innovation is an example of design thinking in action. In 1990, Sternin and his wife, Monique, were invited by the government of Vietnam to develop a model to decrease in a sustainable manner high levels of malnutrition among children in 10,000 villages. Design thinking puts stress on quickly prototyping the solution and tests it so that the designers can take feedback quickly and work on the suggestion at the earliest. There have been many examples of social innovation in the past by the students of Stanford University in countries like Bangladesh, Nepal, India, Pakistan, etc. and many are still ongoing. Design thinking helps people from all disciplines to try and look out for solutions to the pressing situations and problems of the world around. Designers have traditionally focused on enhancing the look and functionality of products. Recently, they have begun using design tools to tackle more complex problems, such as finding ways to provide low-cost healthcare throughout the world. Businesses were first to embrace this new approach 'called design thinking', now nonprofits are beginning to adopt it too.

1.4.5 Design Thinking for Educators

A creative process that helps you design meaning solutions in the class room, at your schools and in your community. It is a structured process for developing and generating ideas such as discovery, interpretation, ideation, experimentation and evolution. Design Thinking is the confidence that everyone can be part of creating a more desirable future, and a

process to take action when faced with a difficult challenge. That kind of optimism is well needed in education.

Classrooms and schools across the world are facing design challenges every single day, from teacher feedback systems to daily schedules. Wherever they fall on the spectrum of scale – the challenges educators are confronted which are real, complex, and varied. And as such, they require new perspectives, new tools, and new approaches. Design Thinking is one of them.

1.5 CHARACTERISTICS OF SUCCESSFUL NEW PRODUCT DEVELOPMENT (NPD)

Inspiration is a requirement for New Product Development (NPD). The sources of inspiration are creative of people. In the case of new product development along with inspiration and idea for new product development, it is important following through executing the idea.

Some common characteristics of successful new product development projects are discussed below:

1.5.1 An Active Product Owner

Many times the client define the need and requests the product development organizations to develop the product of his interest. In an ideal world of new product development the term client does not exist. The client, a product owner actively engages in the project and asserts their ownership, with every development attention to detail, being willing to take responsibility for decisions part of the team and takes the pride of ownership of the product. Effective product owners see the NPD process as collaborative and play a leadership role.

1.5.2 Qualities of Good Problem Solving Team

The new products are developed by a team drawn from different groups who might not be knowing each other. The highest degree of risk always comes from putting together a group of people who have not worked together before and asking them to share a set of goals. This may be unavoidable at times (every team

starts out this way), but assigning an unproven team to a high-priority project requires meticulous attention to detail and strategy, and the interpersonal aspect of resource management becomes a top priority.

Laufer and Hoffman from NASA (who works on NPD) counsel that "to achieve peak team performance you must develop rich, intimate and emotional relationships among skilled people who trust one another and who enjoy spending time with one other."

The following qualities are required for new product design teams.

1.5.3 Intelligence and Creativity

Intelligence can be explained as a thought to involve certain cleverness, combined with the ability to understand and judge. Creativity can be explained as an inspirational force that generates new ideas or combinations of existing ideas, leading to further solutions or deeper understanding. Creativity is often associated with an intuitive, synthesising approach.

Intelligence and creativity are personal characteristics. There is no precise scientific definition or a clear distinction between intelligence and creativity till now. Attempts have been made to measure the level of intelligence of individuals using intelligence tests. The resulting Intelligence Quotients (IQs) provide measures compared to the average of a large sample. For new product development, a minimum level of intelligence is required and it appears that people with high IQ are more likely to be good problem solvers. Creativity tests are often at such a low level that they do not address complex problem solving which involves planning and guiding one's own approach. In new product design, creativity is always focused on a specific goal.

1.5.4 Decision Making Qualities

Often the designer is left with lot of information related to the new product. Decision making play a critical role in designing complex systems. Having well-structured

factual information and applying a systematic approach, and using focused creativity, designers have to master the following in decision making processes.

a) Recognising dependencies in complex systems

The dependencies between the individual elements can vary in strength. Recognising the types and strengths of such dependencies is an essential prerequisite for dividing the problem into more manageable, less complex subproblems or subgoals so that these can be addressed separately.

b) Estimating importance and urgency

Good designers know how to recognise importance and urgency and how to use this information to modify their approach to solve problems. In any design, the most important things are resolved first and the dependent subproblems are tracked next Less significant problems are satisfied with suboptimal solutions by doing this immersing in less relevant issues and thereby losing valuable time can be avoided.

Good problem solvers estimate the time they need accurately. Realistic time planning has a positive effect on thinking processes, and new developments should take place under reasonable time pressure.

c) Continuity and flexibility

Continuity means an appropriate and continuous focus on achieving the goals. Flexibility means an ability to adapt to changing requirements from the clients with time. Good problem solvers find a suitable balance between continuity and flexibility. They demonstrate continuous and consistent, but at the same time flexible behaviour. They stick to the given goals despite any hold-ups and difficulties they encounter.

d) Failures cannot be avoided

In the design of complex systems with strong internal dependencies, it is difficult to avoid failures because it is not possible to recognise all the potential effects simultaneously. In addressing such failures, the most important thing is the way one reacts. It is important to be flexible, supported by the ability to analyse the

reasons for failure and ability to make decisions that lead to corrective actions in all such cases.

Good problem solvers should have the following qualities:

- A sound and structured technical knowledge, i.e. they have a well-structured model in their minds
- Find an appropriate balance between concreteness and abstraction, depending on the situation
- Can deal with uncertainty and fuzzy data
- Continuously focus on the goals while adopting a flexible decision making.

e) Qualities of a good designer

The heuristic competencies depend largely on personal characteristics, but can be developed considerably through training on different types of problem. Good designers demonstrate the following qualities:

- Thoroughly analyse the goals at the beginning of a task and continue to do so throughout the design process.
- First generate or identify the most suitable solution principles in a conceptual phase.
- Initially adopt a diverging search without generating too many variants and then quickly converge onto a small number of solutions
- Regularly assess their solutions using a comprehensive set of criteria, avoiding emphasising personal preferences.
- Continuously reflect on their approach and adapt it to the situation at hand

1.5.5 Clear Objectives

In new product development, the objectives should be clear in the beginning with respect to originality, invention, innovation, adaptive or variant design.

One source of new product development is a request or order from a client. This is typical of made-to-order systems in engineering equipment as well as for supply chain companies. For this type of order, there is a new from client orientation to client

integration which has an influence on the work of the design and development department.

In this type New Product Development, the assignments originate in the special planning departments of companies. The designers are bound by the planning ideas of others. The special skills of designers prove to be most useful in the medium- and long-term planning of products. The senior staff of the design department should maintain close contacts with the production and product planning departments.

Planning can also be done by outside bodies, for instance by clients, by authorities, by consultancies, etc. in order to make the objectives of the product clear.

1.5.6 Novelty of Product

Every new product should have a novelty in order to meet the people requirements. The designers play an important role with different development tasks can have different degrees of novelty. Themajority of tasks are adaptations to and variations on existing designs. The following design tasks is of interest in New Product Development.

1. ***Original design:*** *A n*ew product development is made using new or novel combinations of known solution principles. Two different cases in original design are invention and innovation:
   i) An invention is a unique or novel device, method, composition or process that has been created or made up in an overall engineering and product development process. It may be an improvement upon a machine or product or a new process for creating an object or a result. An invention that achieves a completely unique function or result may be a radical breakthrough. An inventor may be taking a big step toward success or failure. It is often an exploratory process with an uncertain or unknown outcome. Inspiration can start the process, but no matter how complete the initial idea, inventions typically must be developed. For example, the odd metallic color of plastic made by accidentally adding a thousand times too much catalyst led scientists

to explore its metal-like properties, inventing electrically conductive plastic and light emitting plastic—an invention that won the Nobel Prize in 2000 and has led to innovative lighting, display screens, wallpaper and much more.

Some inventions can be patented. A patent legally protects the intellectual property rights of the inventor and legally recognizes that a claimed invention is actually an invention. The rules and requirements for patenting an invention vary by country. The technological inventions are age old. The earliest technology made nearly two million years ago, stone tools are the first known technological invention. It comes from an early human campsite in the bottom layer of deposits in Olduvai Gorge, Tanzania.

The Egyptians, invented technology for building pyramids centuries before the creation of modern tools. They invented many simple machine such as the ramp to aid construction processes. Currently, Switzerland is considered the world leader in innovation, which is generally a much broader term than "invention." Moreover, the United States, nevertheless, has the most scientific journals, patents issued, etc., in recent years.

ii) "Innovation is the creation, development and implementation of a new product, process or service, with the aim of improving efficiency, effectiveness or competitive advantage." as per the Government of New Zealand. "Innovation is the successful exploitation of new ideas." as per UK Department of Innovation and Skills.

The innovations include technological inventions such as wind turbines, photovoltaic cells, concentrated solar power, geothermal energy, ocean wave power and many others.

The four different types of innovation are

i) Incremental innovation involves making small scale improvements to add or sustain value to existing products, services and processes

ii) Disruptive innovation is an innovation that creates a new market and value network and eventually disrupts an existing market and value network, displacing established market-leading firms, products, and alliances,

iii) Architectural Innovation refers to innovation in the architecture of a product that modifies or changes the way different components of the systems interact or link with each other

iv) Radical innovation is an invention that destroys or supplants an existing business model. Unlike architectural or incremental innovation, radical innovation blows up the existing system or process and replaces it with something entirely new

The four Key Elements of Innovation:

i) Collaboration ii) Ideation

ii) Implementation iv) Value Creation

A firm can innovate successful only if its internal as well as external conditions are supportive. Some of the necessary conditions for innovation include: Employees should be given freedom and leaving room in budgets, promoting open communication, etc. to accelerate innovation within the organization.

2. ***Adaptive design:*** This form of design also 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 design is the process in which the parameters of the existing design or engineering device is slightly modified to improve quality or to suit a new trend in the market.
3. ***Variant design:*** The sizes and arrangements of parts and assemblies are varied within the limits set by previously designed product structures, which is typical of size ranges and modular products. Ex: Front load and top load washing machines, automobiles with 4 cylinders and 6 cylinder engines.

1.6 IDENTIFICATION OF OPPORTUNITIES

A successful NPD project requires a thorough understanding of a list of items viz. target market, the market need, unique value proposition, competition, pricing options etc. There is no point launching a product without knowing anything about target market, or the new product does not have anything setting it apart from the competition.

1.6.1 Identifying Needs and Trends

Most important is the identification of customer needs and market trends. These come from changes in customer behaviour caused, for example, by social developments such as environmental awareness, disposal problems, reduction in the working week, and transport problems.

1.6.2 Identifying Strategic Opportunities

It is possible that some preliminary gaps in the current product range or in the market are identified during the analysis. A promising gap must be found by taking into account the company's goals, strengths and market calls these strategic opportunities. They can relate to profit, market share, type of industry and product range. The weightings listed in Table 1.1 indicate that company goals are the most important criteria.

1.7 PRODUCT DEVELOPMENT PROCESS

In the previous sections we examined the fundamentals on which design work should be built to best advantage. They form the basis of a systematic approach which practicing designers can follow, regardless of their specialty. The approach is not based on one method but applies known and less well known methods where they are most suitable and useful for specific tasks and working steps.

Table 1.1. Decision criteria for product planning

Criteria	Weighting
Company goals	**≥ 50% sufficient**
financial cover	
Good turnover	
Fast market growth	
Large market share (market leader)	
Short-term market opportunity	
Good functional advantages for users and excellent quality	
Differentiation from competitors	
Company strengths	**≥ 30%**
Excellent know-how	
Opportunities for extension to range and/or product programme (diversification)	
Significant market position	
No big need for investment	
Minimum sourcing problems	
Favourable rationalisation potential	
Market and other sources	**≥ 20%**
Small danger of substitution	
Poor competition	
Favourable patent status	
Not many general restrictions	

1.7.1 Company Goals and their Effect

The main goal of any company is to make a profit. This goal can be divided into two strategies.

(i) The first strategy is sales base, large volumes, and rigorous product standardization.

(ii) The second is strategy performance differentiation.

The goals and strategies focus on sales in special areas, highly effective flexible production, and specialization in design and development. Both strategies have a time component, which is reflected in the company goal of being quicker to reach the market with a new product than its competitors. Both the goals focus on cost leadership and performance differentiation that affect the design and development. At the next level down, many detailed goals are established, including those relating to the:

- *Product:* Such as functionality and properties
- *Market:* Such as time-to-market, which influences the time and budget made available.

It is therefore very important for the design and development department to know the goals of the company, their interrelationship and their relative importance. An important task for senior engineering managers is to convey the company goals relevant to engineering effectively to every member of staff.

1.7.2 Definiting Products

Product ideas, after elaboration, are subjected to an evaluation. The best product definitions are given to the product development department along with product proposal together with a preliminary requirements list. The product development department then develops the actual product.

The product proposal should have the following information.

i) Description of the intended function

ii) Preliminary requirements list that should have been compiled using the characteristics used later to clarify the task and finalise the requirements list.

iii) Formulations requirements in a solution neutral way. The working principle should only be determined in so far as it is really necessary from the point of view of the overall functionality

iv) Cost target linked to the company's goals which clarifies future intentions such as production volume, extensions to the product range, new suppliers etc.,

1.7.3 Finding Product Ideas

Successful new product development projects avoid the temptation of doing too many changes. The tendency to keep adding features more than the point of usefulness is called feature creep. It is a problem because it can lead products that are needlessly complex and difficult to use. Therefore it is necessary to avoid feature creep in any new product development process.

Different ideas may be encouraged by the general relationships in technical products and their particular level of concretization. Depending on the degree of novelty, the starting points for new products can be new product functions; other working principles; new embodiments; and rearrangements of an existing or new system structure as discussed below.

a) Product function:

The designer should be aware of product functions, client usage and future of the product. He has to get answers to the following questions:

i) Which functions are required by the client?

ii) Which functions do we already fulfil?

iii) What complements existing functions?

iv) Which functions represent a generalisation of the existing ones?
For example, until now our company has only transported unit loads overland.

v) What can we do in the future?

vi) Should we also use waterways?

vii) Should we start transporting very large, heavy items?

viii) Should we also transport bulk goods?

ix) Should we try to solve transport problems in general?

b) Working principle:

Existing products are based on a specific working principle. Would a change of working principle lead to better products?

Characteristics to look for are the types of energy and physical effects. For example, the design of a temperature-dependent flow-rate controller be based on the principle of fluid expansion, the bimetallic effect or the use of microprocessor-controlled temperature probes?

c) Embodiment:

i) Is the space used still appropriate?

ii) Should we focus on miniaturization

iii) Is the shape still appealing?

iv) Could the ergonomics be better?

For example, whether to continue to use laces in shoes or Velcro or hooks be more appealing and more comfortable.

The answers to these questions determine the novelty of the product idea and therefore the developmental risks.

1.7.4 A Product Roadmap

Having a great idea is only the tip of the iceberg when it comes to developing a new product. Any great idea and inspiration, you will need to follow through with a great strategy. A product roadmap is a high-level visual summary that maps out the vision and direction of your product offering over time. A product roadmap communicates the why and what behind what you are building. A roadmap is a guiding strategic document as well as a plan for executing the product strategy.

The product roadmap lays out the big efforts required to meet overall business objectives and the timeline for implementing features and requirements that align with strategy. It should be separate from other planning materials, such as lists of ideas and

feature requests, a backlog of work, or bug reports. Those materials inform what goes on the roadmap, after careful review and considerations. Roadmaps evolve.

a) Why is roadmapping important?

Roadmapping is an essential part of your strategic planning process. The exercise can be a forcing factor for conversations about where you will invest and why. Connecting your product strategy to implementation drives alignment and keeps everyone focused on the work that matters most to achieving the vision. You can visually communicate the direction of your product to internal teams and external partners. Visibility into what is coming next helps the entire organization prioritize and plan for the new experience you will deliver.

Your work as a product manager impacts other groups, and you need their input and participation to deliver a Complete Product Experience (CPE). This is why the best product roadmaps include cross-functional teams and factors. For example, marketing can prepare for more impactful launches and campaigns, IT can improve the overall technical infrastructure, and sales can better set customer expectations. The more inclusive your roadmapping process is, the greater organizational alignment and support you will have when you release that new experience.

b) How to build a product roadmap

Before building your product roadmap, you must know the business goals that your efforts will support and define the initiatives you will invest in to support those objectives. Once you have a high-level product plan, you can decide which releases and features are best aligned, then visualize it all on a timeline experience.

c) What you show on your roadmap depends on your intended audience

For example, the leadership team will want to understand the strategic importance of what you will deliver, conveyed through roll-up relationships between major releases and associated goals and initiatives.

Customers, on the other hand, will be more interested in seeing the theme of the release and any critical functionality they need. And of course, you would not likely want to show more detail than that anyway. For example, you might choose to show an external release date to customers that is different than your internal release date. Or you might use a broader time frame (e.g., show releases by quarter) on your customer-facing product roadmap so that you have flexibility to shift delivery dates if necessary

It is necessary to have a road map set on attainable objectives that respond to time-to-market requirements with enough flexibility to absorb unpredictable events like the emergence of competitors, macro economic factors, organizational change, and new opportunities for effective new product development. Projecting at least two iterations down the road is desirable, with longer-term objectives described and understood without necessarily being defined into actionable work.

1.8 PRODUCT PLANNING

Due to strong competition, new products have to meet market needs at a competitive cost and be economical to use. In addition, requirements related to disposal, recycling, low environmental impact during production and use are becoming increasingly important. Just relying on spontaneous ideas or incremental developments to existing products will not, in general, fulfil these demands. Systematic product planning is essential between the two departments.

The following are important guidelines:

i) Depending on the size of the company setting up interdisciplinary project groups or involving external consultants to supply may be decided.

Company expertise can involve less risk and often increases client confidence.

ii) If product planning focuses on existing product variation, the development department responsible for the product line can monitor the new product.

iii) When product planning is outside an existing product line, it is better to set up a new planning group, which can work on "innovative planning".

iv) To identify customer problems, it is useful to have intensive collaboration with a few leading clients, referred to as "lead users".

v) When new products are introduced, technical failures and weaknesses can have a far-reaching impact on the reputation of such products hence sufficient time for testing is essential.

vi) During the planning and introduction of new products, it is useful to have a powerful product champion.

1.8.1 General Problem Solving Process

The problem solving method involves step-by-step analysis and synthesis. In this, we proceed from the qualitative to the quantitative. For the general problem solving process, planning is an important phase in design. These plans and procedures assist in identifying what has to be done.

The procedural plans have to be adapted to specific situations in a flexible manner. For example, it is possible to leave out certain steps or order them in another sequence. Given the complexity of the product development process, it is desirable to have a procedural plan to avoid unmanageable number of possible approaches. It is necessary for designers to know decision making steps in the procedural plans in problem solving.

A systematic approach aims to keep the iteration loops as small as possible in order to make design work effective and efficient. It would be a disaster if the design team had to start again at the beginning having reached the end of a product development to address a few important issues are missed for consideration in the beginning

The division in working and decision making steps ensures necessary and permanent links between objectives, planning, execution (organisation) and control scheme for the general problem solving process is shown in Fig 1.5.

Every task involves an initial confrontation of the problem, which involves learning what is known or not known. The intensity of this confrontation depends on the knowledge, ability and experience of the designers, and on the particular field in which they are engaged. In all cases, however, more detailed information about the task itself, about the constraints, about possible solution principles and about known solutions for similar problems is extremely useful

The definition phase essential problems are defined on a more abstract plane, in order to set the objectives and main constraints.

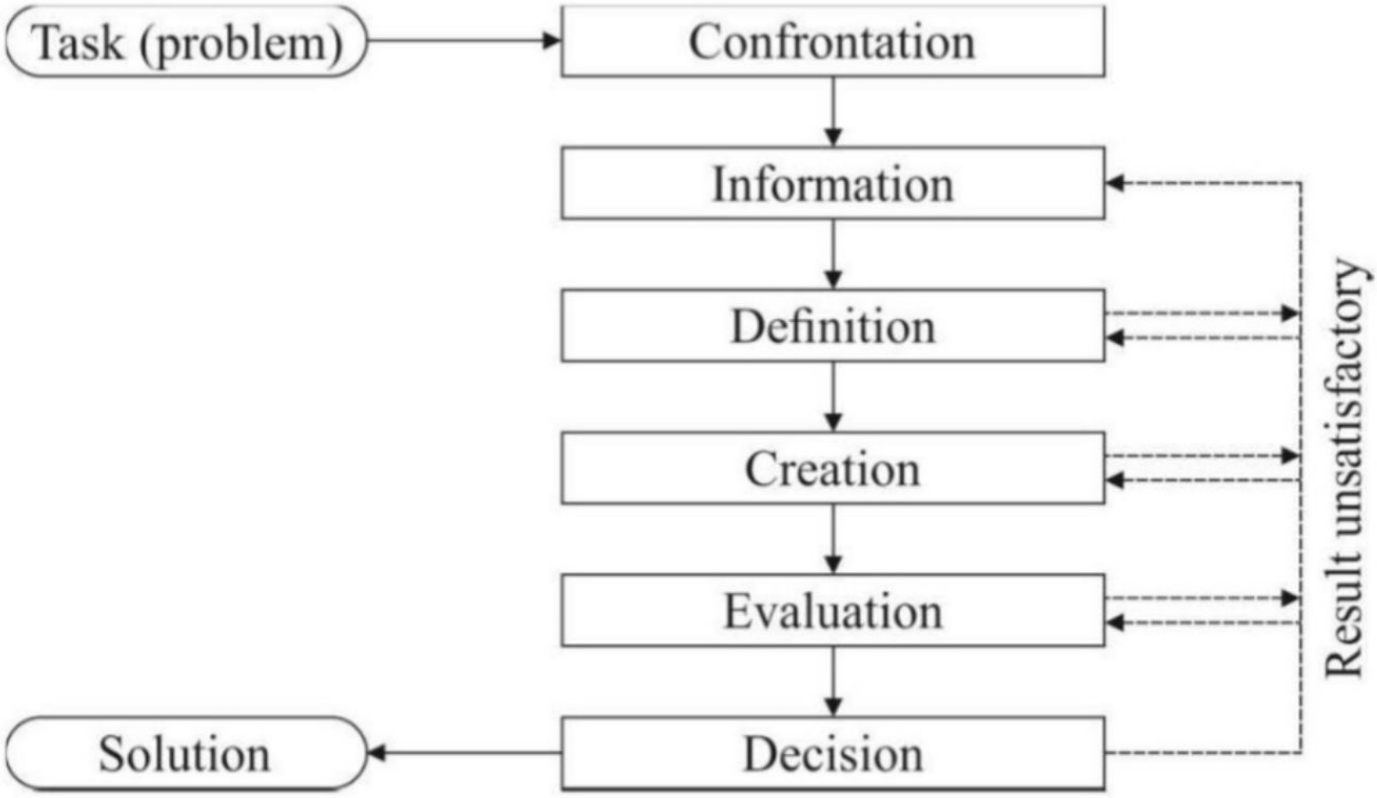

Fig. 1.5 General problem solving process

In the creation phase, solutions are developed by various means and then varied and combined using methodical guidelines. If the number of variants is large, there must also be an evaluation which is then used to select the best variant through a decision.

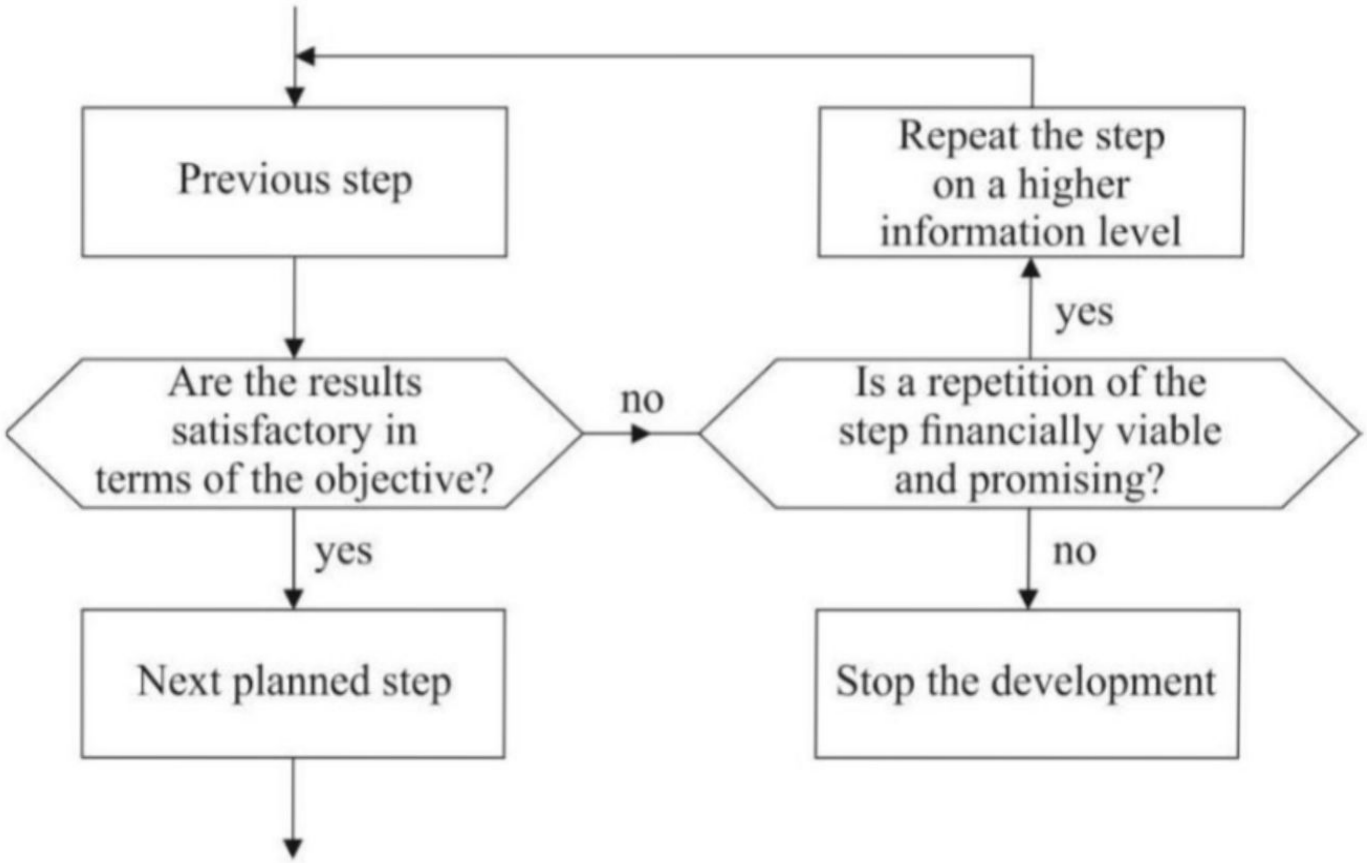

Fig. 1.6 General decision making process

Following considerations are involved in decision making as shown in Fig. 1.6.

1. The next step can be started after the meeting the objective of first step. If the results are incompatible with the objective, the next step should not be taken if there is any incompatibility of results with the objective in the first step.
2. If there is incompatibility in meeting with the objective, previous steps have to be repeated.
3. If the answer to the previous question is no, the development idea must be stopped and new ideas to be given a thought. This whole process, leading from confrontation through creation to decision, must be repeated in each successive, increasingly concrete, phase of the design process.

1.8.2 Flow of Work During the Process of Designing

The product design and development planning demand the following:

i) The required activities for the proposed project

ii) The timing and scheduling of these activities

iii) The project and product costs.

The activities and their durations strongly depend on the development is for an original, adaptive or variant design. The planning and design process is divided into the following main phases:

i) Planning and task clarification: specification of information
ii) Conceptual design: specification of principle solution (concept)
iii) Embodiment design: specification of layout (construction)
iv) Detail design: specification of production.

The working steps proposed for each of the main phases are termed the main working steps as shown in Fig. 1.7. The results of these main working steps provide the basis for the subsequent working steps.

1.8.3 Planning Project and Product Costs

The cost price is the basis for determining the selling price and is therefore crucial to the success of the product. The cost price is influenced by the manufacturing costs and the associated project costs. Design and development are the costliest items contributing to the project cost, hence, engineering departments carry a great responsibility

In order to meet the target cost price, engineering departments not only have to keep manufacturing costs to a minimum, but also the design and development costs. The main costs incurred by engineering departments are staff costs. Support costs, such as facilities, CAD systems, external consultants, etc., are usually much lower. It is useful to build a small core team with the experts who are responsible for design, production planning, marketing and sales. The composition of the team depends on the particular problem and type of product. The knowledge domains that support the design and development is shown in Fig. 1.8

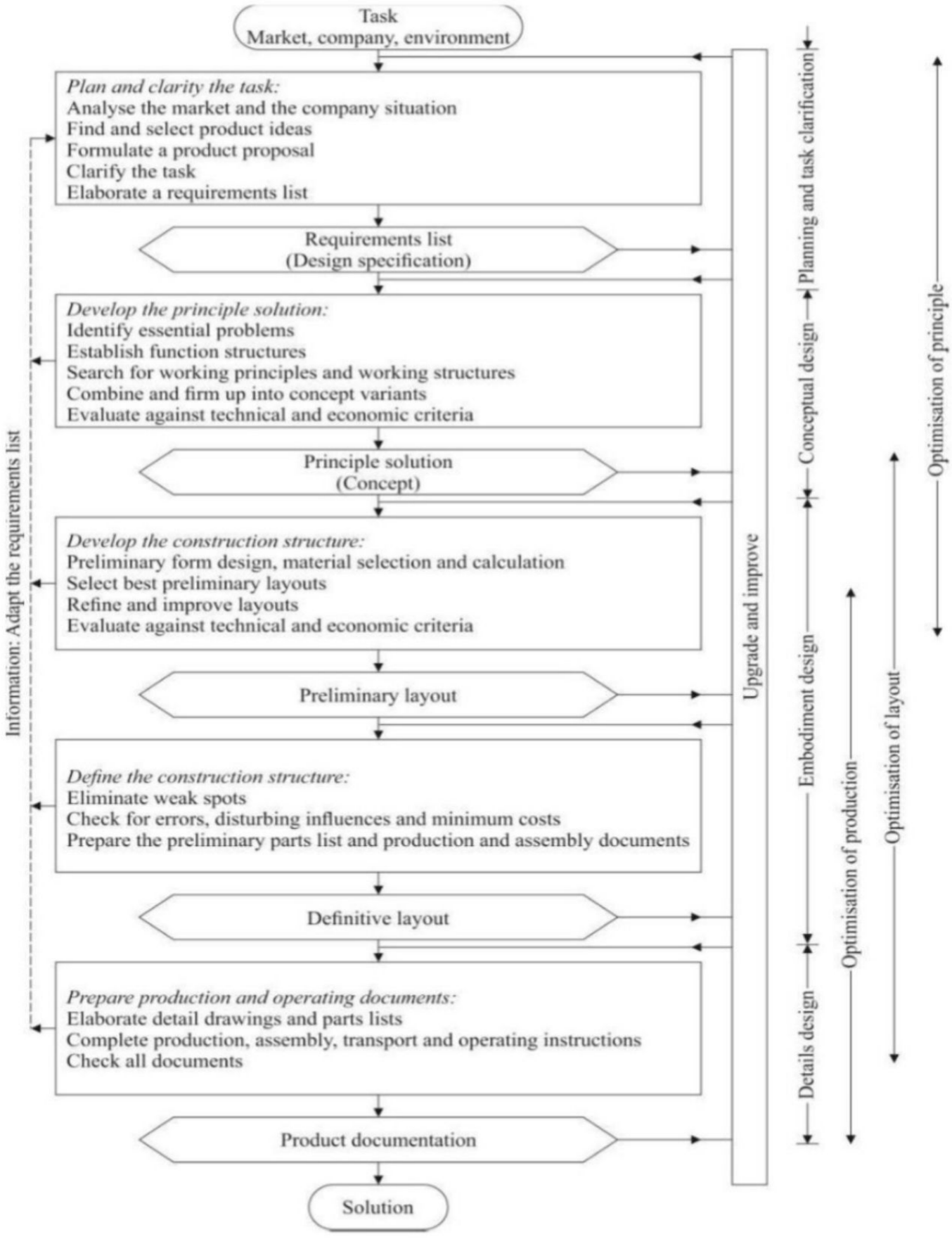

Fig. 1.7 Steps in the planning and design process

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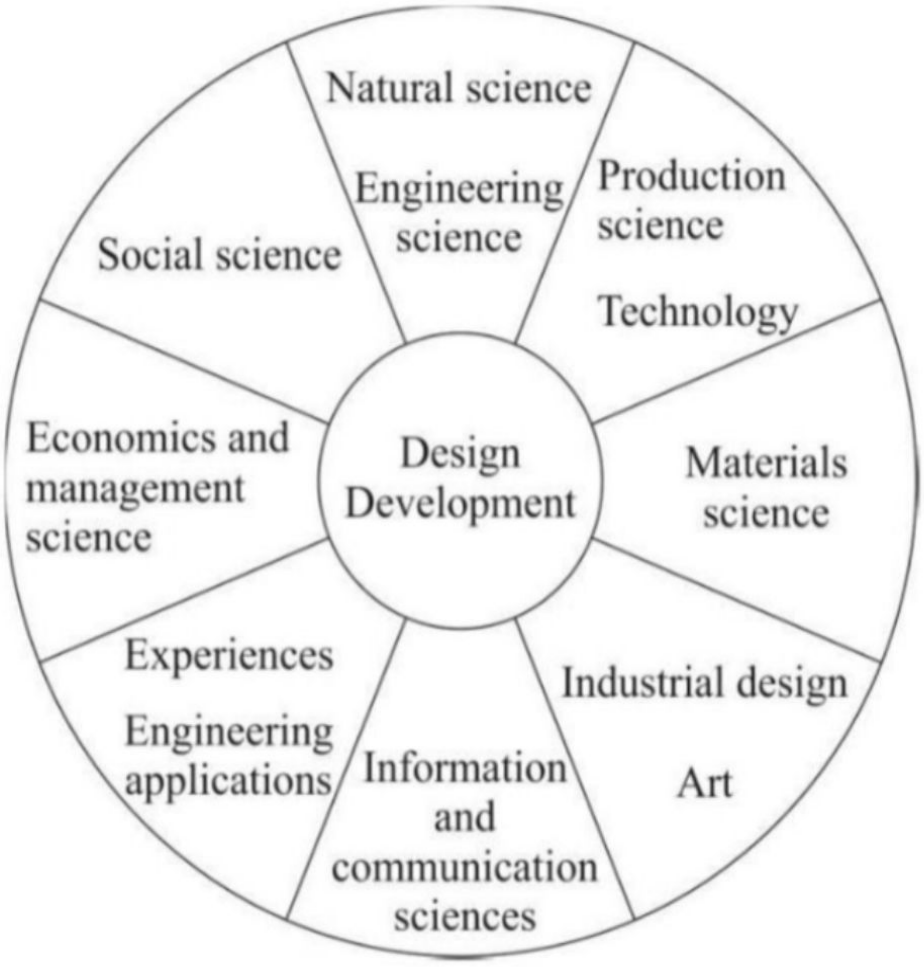

Fig. 1.8 Related knowledge domains that support design and development

1.9 INNOVATION IN PRODUCT PLANNING

Design and development team start their work using a task description. In many cases, in particular in small- and medium-sized companies, it is left to the good sense of a director, or an individual member of staff, to develop and introduce the right product ideas at the right time and to formulate the necessary tasks. In larger companies, however, systematic procedures are increasingly used to develop new products. An important aspect of this systematic approach is its potential to monitor the time and cost of product planning and product development more accurately. Those involved in product planning include marketing staff and product managers.

The most important factor in finding new product ideas is client focus directed towards client integration. Several systematic product planning approaches exist and all of them have much in common as shown in Fig. 1.9. The two important aspects are marketing and environmental and progress made in the company.

a) Stimuli for new product development come from the market include:
   i) The technical and economic position of the products of a company in the market.
   ii) Changes in market requirements, for example new functions or fashions
   iii) Suggestions and complaints from customers
   iv) The technical and economic superiority of competing products.

b) Stimuli from the environment include:
   i) Economic and political changes, for example oil price increases, resource shortages, transport restrictions
   ii) New technologies and research results, for example microelectronics replacing mechanical solutions or laser cutting replacing flame cutting
   iii) Environmental and recycling issues.

c) Stimuli from within the company include:
   i) New ideas and results from company research applied during development and production
   ii) New functions added to extend or satisfy the market
   iii) The introduction of new production methods
   iv) Rationalization of the product range and production
   v) Increasing the degree of product diversification, that is, creating a range of products with life cycles that are intended to overlap.

These external and internal stimuli initiate five main working steps, which are illustrated, along with their outputs, in Fig. 1.9.

1.9.1 Product Life Cycle

Every product has a life cycle estimates as shown in Fig.1.10. The cycle time depends strongly on the type of product. In general cycles times are becoming shorter and this trend is likely to continue. This has a large effect on work in the design and development department and allotment time for different tasks.

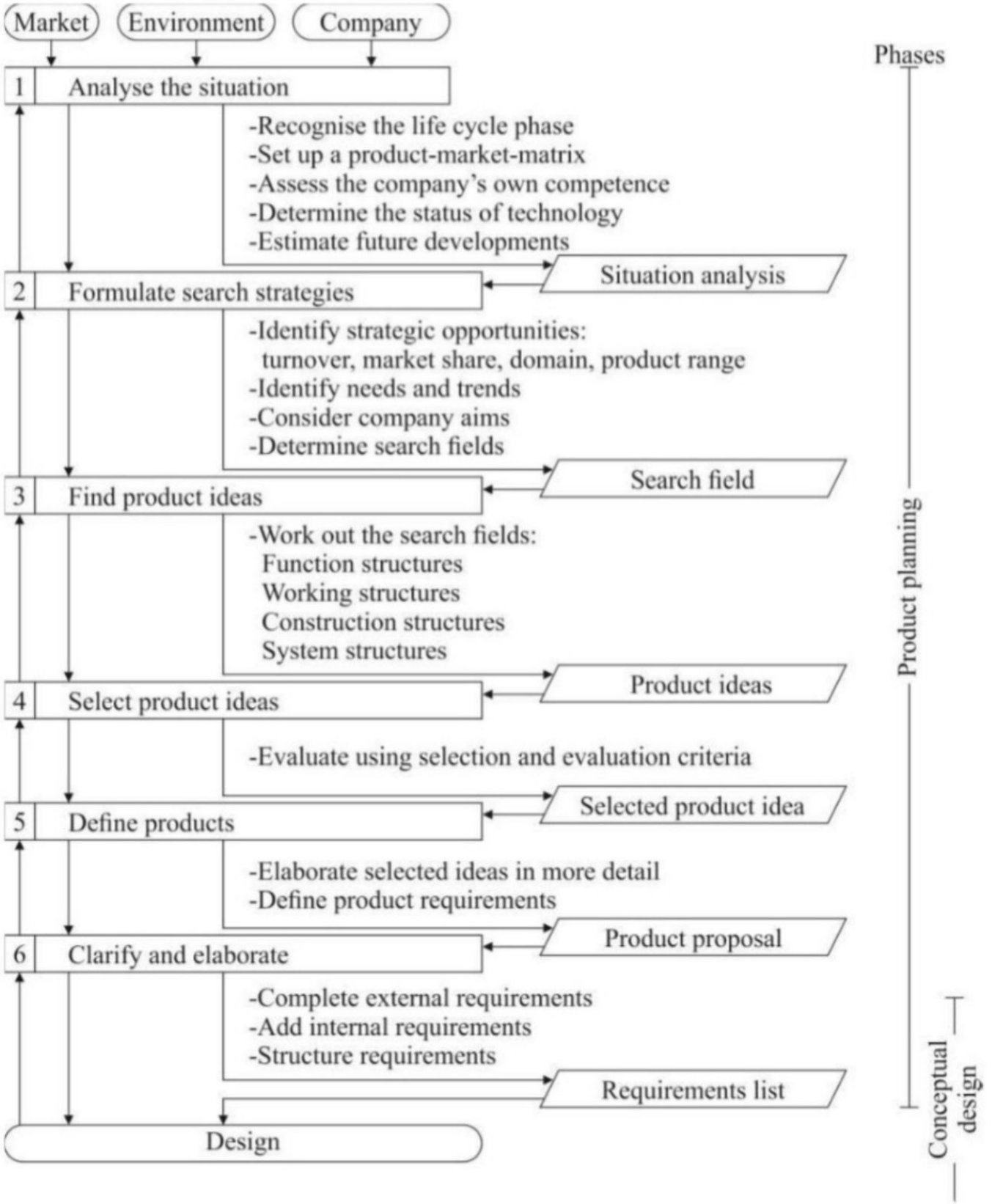

Fig. 1.9 Product Planning Procedure

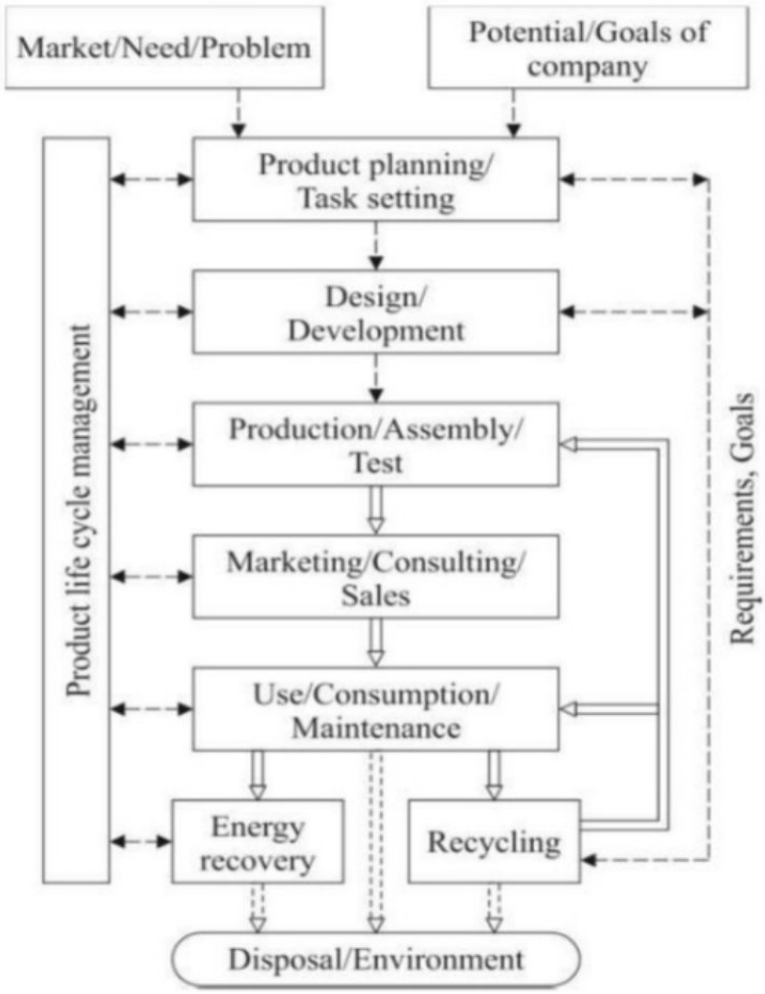

Fig. 1.10 Product Life Cycle

1.9.2 Difficulties in New Product Development Planning

Some of the primary management factors that make innovation and new product development difficult for many companies are:

i) Disconnect between the projects new product development R&D teams work on versus current strategic business strategies and growth objectives

ii) Project and investment decisions are made to support pet projects and politics, rather than using fact-based data to make the right decisions.

iii) Project teams work on too many projects which strains resources and results in too few high-quality initiatives coming to market, and usually late when they do.

iv) Project teams lack prioritization and direction on which key strategic initiatives to work on

v) Short term financial decisions whip-saw plans and resources, resulting in too few really new or major initiatives coming to market

The feed-back on difficulties can be summarised as follow:

i) Gaps in Alignment: 94% have a gap in alignment between product development growth strategies

ii) Decision Making: 85% make investment decisions based on politics rather than data

iii) Too many Low-Value Project: 59% say their resources are "stretched too thin" because of too many active projects

1.9.3 Create Achievable Objectives Aligned with the Vision.

Research has demonstrated that best practices in innovation planning use a strategic approach. The traditional Project and Portfolio Management (PPM) approach is bottom-up-rolling up existing projects to see the status and how they stack up. This rearranges what's already in process regardless of alignment with strategic objectives. The better approach is the top-down strategic approach-first focus on the business strategies and objectives, and use these to drive portfolio, project and investment decisions. This approach aligns innovation and new product development plans with the business strategic objectives. Strategy is needed before execution. Following the traditional approach may improve execution. But the results won't produce value or support the business objectives. Relevant innovation and new product development performance metrics must be established that align with the plan.

1.9.4 Innovation Measurements for Success

i) Establishing a planning framework is key to developing, communicating and building transformational strategies.

ii) Innovation and new product development success is unique to your company, brand, product and market:

- Sustained and scalable innovation can only occur with actionable line of sight
- Effective plans allow for projects to be judged in merit of a portfolio, not as a stand alone entity.

iii) Innovation targets should not feel bureaucratic to the teams, they should be engaging.

iv) Success metrics must support and drive strategic innovation and new product development success.

"Perhaps what you measure is what you get. More likely, what you measure is all you'll get. What you don't (or can't) measure is lost"

– H Thomson Johnson

Innovation and new product development is a cross-functional process. Strategies and objectives can be initiated by different and/or multiple functional areas of the business. Marketing may drive a strategy to penetrate new or additional market segments. Product management may drive innovation for entry in a new or different product category. R&D may drive innovation of new technology that supersedes or disrupts current capabilities. Project teams need to work across functions to gain agreement on direction and make long-term plans real. This way, when one is ready to make the required investment decisions, all stakeholders have confidence that these investments are aligned with future growth plans. This cross-functional line of sight must be real-time to make decisions and adjustments dynamically.

REVISION QUESTIONS

1. What is design?
2. What are the considerations for a new product or service initiative?
3. Explain design methodology.
4. What are the factors in design methodology?
5. What is proximity design? Explain with one example.
6. How do you use design thinking in everyday life?
7. What are the decision making qualities?
8. What do you understand by the terms "Invention" and "Innovation"?
9. What are the key elements of innovation?
10. Explain the criteria for product planning.
11. What are the characteristics of successful new product development?
12. What are the qualities of a good engineer?
13. How do you measure an innovation for success?
14. Explain product development process.
15. What is a product roadmap?
16. What is the importance of a product road map?
17. How do you build a product roadmap?
18. Explain the steps in the planning and design process.
19. Explain the knowledge domains required in the design and development of a product.
20. How do you plan for product diversification?
21. Explain the problem solving process.
22. How do you plan project and product costs?

23. Explain product planning procedure.
24. What do you understand by product lifecycle?
25. What are adaptive and variant designers?

DESIGN PROBLEMS FOR PRACTICE

Solar energy is the transformation of heat energy that comes from the sun. The oldest uses of solar energy is for heating, cooking, and drying. Today, it is also used to make electricity.

It is becoming cheaper to make electricity from solar energy. Because the Sun always gives heat, solar energy can be considered a renewable energy and an alternative to non-renewable resources like coal and mineral oil (petroleum).

Solar energy is used in a number of ways:

i. As heat for making hot water, heating buildings and cooking
ii. To generate electricity with solar cells or heat engines
iii. To take the salt away from sea water.
iv. To use sun rays for drying clothes and towels.
v. To use for cooking (solar cookers)

1. Solar-powered water purification

Purified water is a big issue facing many communities in the developing world in particular. Those in rural areas are usually too isolated for on-grid government-funded water pipe infrastructure to be built; and so the responsibility of getting clean water becomes that of the women and their children in the villages who have to walk long distances to water sources that are not necessarily the purest.

Design a solar-powered water purification system for rural poor.

2. Solar-powered drip irrigation (SPDI) System

Drip irrigation is a type of micro-irrigation system that has the potential to save water and nutrients by allowing water to drip slowly to the roots of the plants, either from

above the soil surface or buried below the surface. The soil is to place water directly into the root zone and minimize evaporation.

Design a SPDI system for Indian dry land conditions.

3. Seawater for drinking

Many coastal cities are facing shortage of drinking water. Abundant seawater is available. Purification of seawater with electricity or diesel is very expensive.

Design a solar water purification system from the seawater

4. Solar room heating

In some parts of our country, winter is very cold requiring room heaters.

Design a solar room heating system.

5. Design a foot operated irrigation pump to draw water from a well or a stream.

6. There are number of variations in the two wheeler market in the past decade. Study the variations. Make a report on the developments for safety, convenience and aesthetics to attract the customers.

7. Differentiate the features of a small car, Sedan, Hatchback and SUV.

8. Sketch the parts of a ball point pen. Explain how ball works in the flow control of ink.

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