Module IV

Design Engineering Concepts

Contents

- Design Engineering Concepts:-Project-based Learning and Problem-based Learning in Design.
- Modular Design and Life Cycle Design Approaches.
- Application of Biomimicry
- Aesthetics and Ergonomics in Design.
- Value Engineering
- Concurrent Engineering
- Reverse Engineering

- There is growing evidence of the need to prepare engineering students for the future world in which they will practice as professionals.
- Educational practices that over-emphasise theory alone are outdated, as it is important for students to not only gain knowledge about engineering, but also to learn how to be an engineer.
- In order for students to practice as engineers, they need to have had exposure to a number of projects that over real world problems, along with the complexity and uncertainty of factors that influence such problems
- Learning to apply theoretical principles is much better done when given real problems and hands-on activities in projects.

Design Engineering

1. Problem-based Learning
2. Project-based Learning

Problem-based Learning in Design

- **How students can take up problems to learn design engineering?**
- It empowers learners to conduct research, integrate theory and practice and apply knowledge and skills to develop a viable solution to a defined problem.
- It is a teaching pedagogy which is student centered.
- Student learn about a topic through the solving of problems and generally work in groups to solve the problem where there is no one correct answer.
- Problem-based Learning crosses a broad spectrum of instructional patterns, from total teacher control to more emphasis on self directed student inquiry.

Key Characteristics

1. **Problem-based**: It begins with the presentation of a real life (authentic) problem stated as it might be encountered by practitioners.

2. **Problem-solving**: It supports the application of problem-solving skills required in “practice". The role of the instructor is to facilitate the application and development of effective problem-solving processes.

3. **Student-centred**: Students assume responsibility for their own learning and faculty act as facilitators. Instructors must avoid making students dependent on them for what they should learn and know.

    1. Strategies used: Using library resources, Using general reference text books, Preparing for class sessions, When working in groups, each person looks up one topic and then explains it to others etc.

4. **Self-directed learning**: It develops research skills. Students need to learn how to get information when it is needed and will be current, as this is an essential skill for professional performance.

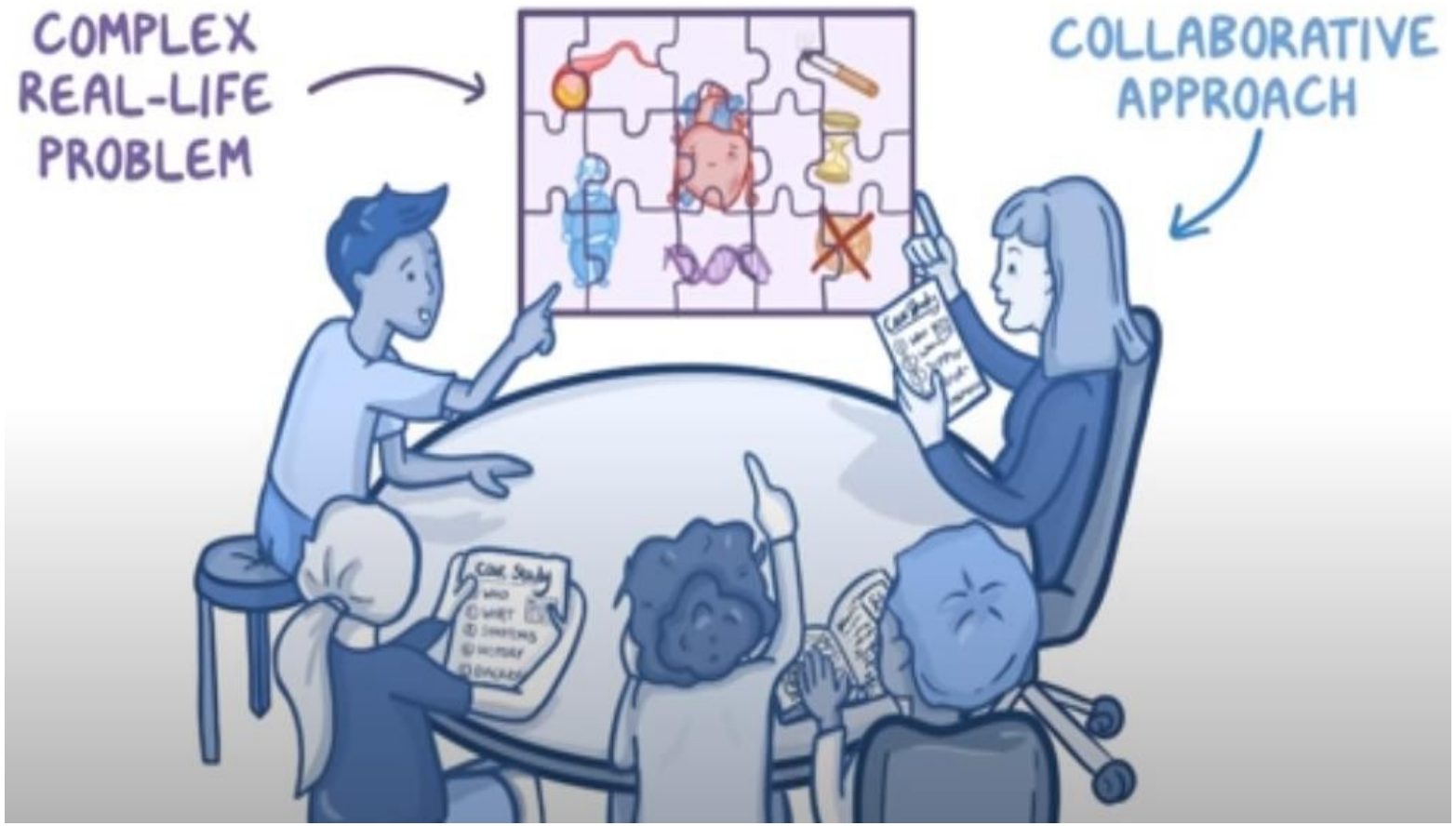
5. **Reflection**: This should take place following the completion of problem work, preferably through group discussion, and is meant to enhance transfer of learning to new problems.

Problem-based Learning in Design

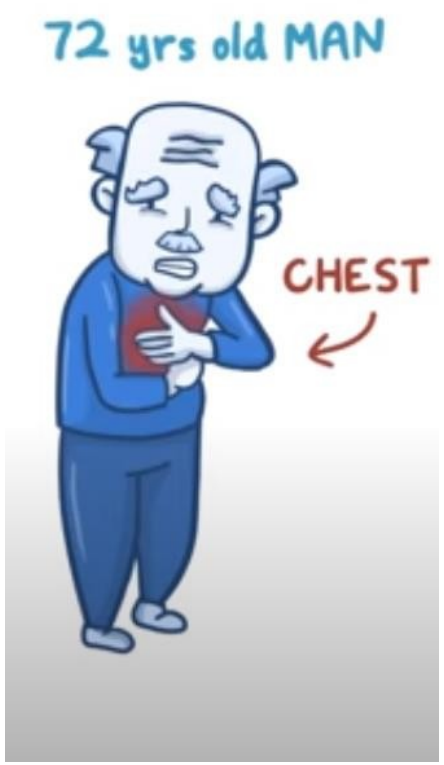
- Steps:

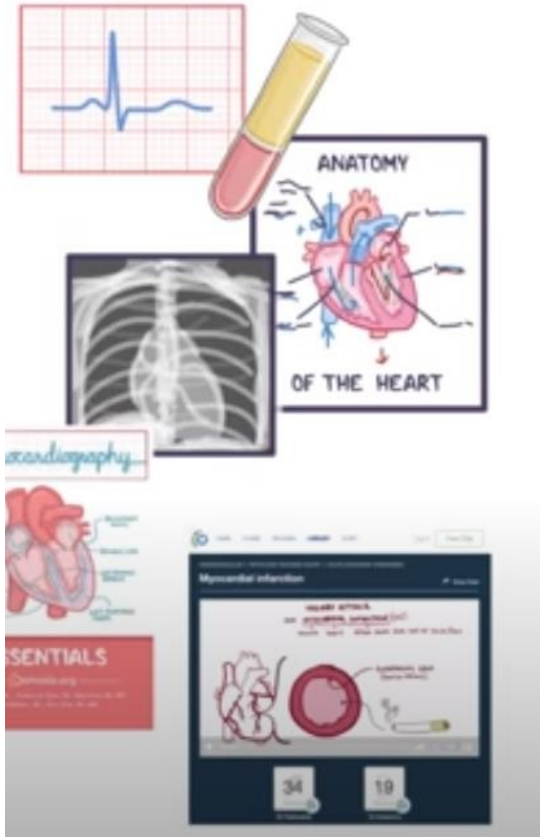
1. Presentation of an "ill-structured" (open-ended, "messy") problem
2. Problem definition or formulation (the problem statement)
3. Generation of a "knowledge inventory" (a list of "what we know about the problem" and "what we need to know")
4. Generation of possible solutions
5. Formulation of learning issues for self-directed and coached learning
6. Sharing of findings and solutions

Problem-Based Learning



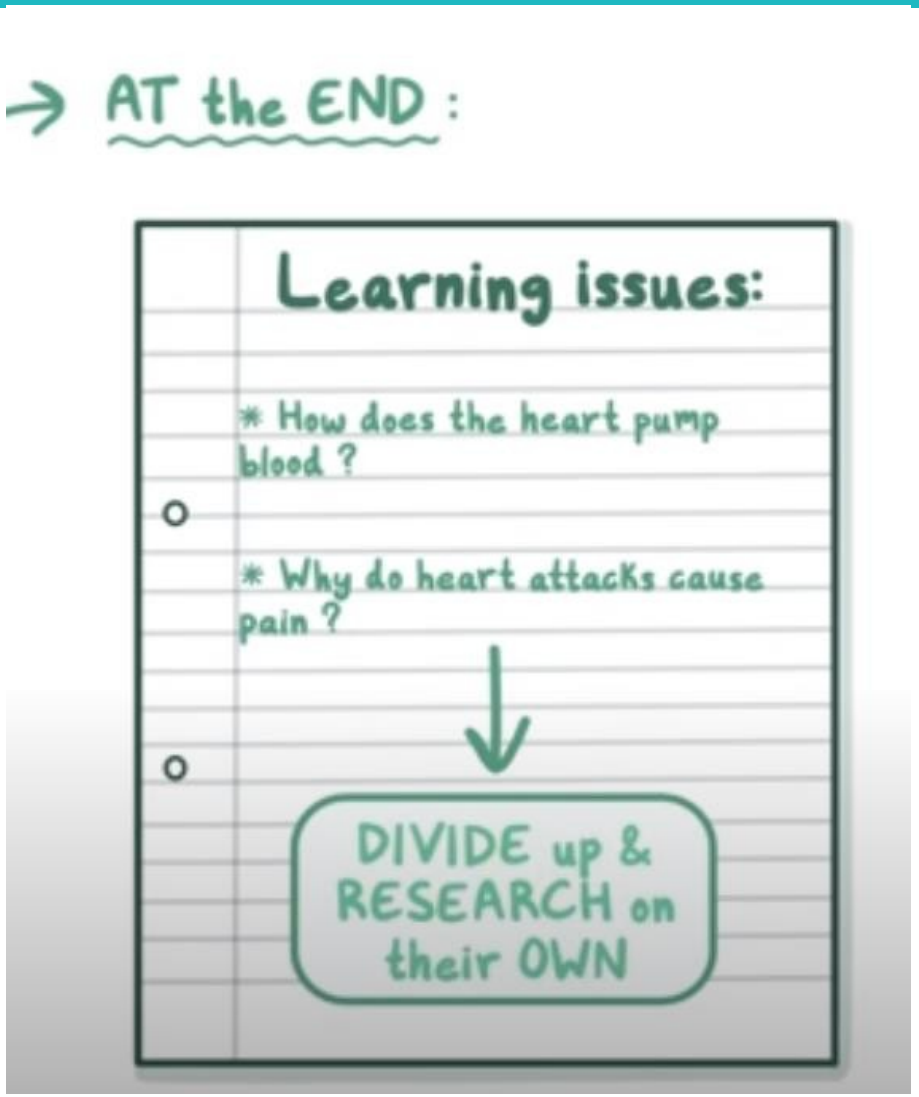
Problem-Based Learning



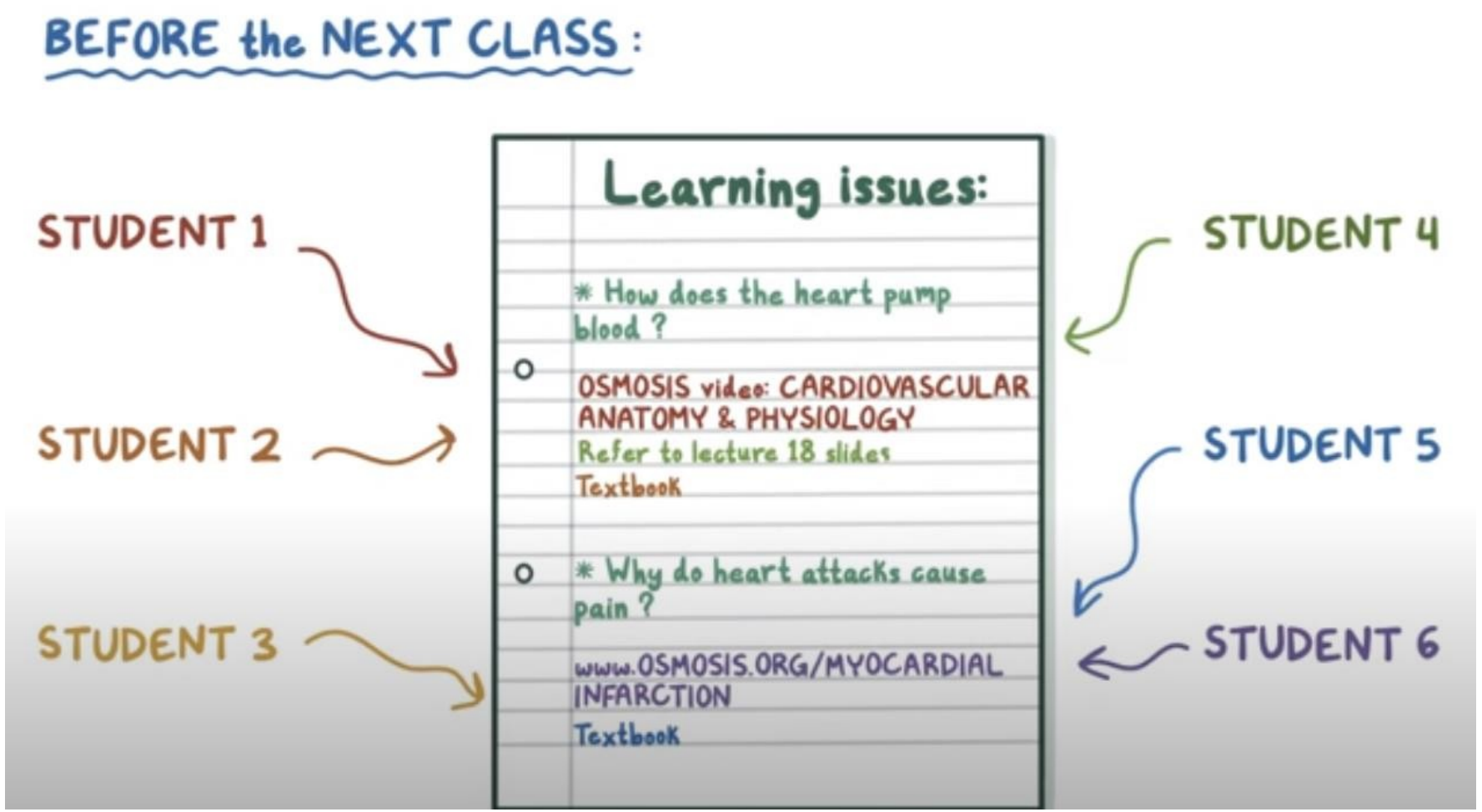


Problem-Based Learning

Problem-Based Learning



Problem-Based Learning



Problem-Based Learning

APPLY NEW INFO to the CASE

DEEPER and RICHER UNDERSTANDING

MORE EASILY REMEMBERED !

Problem-Based Learning

- **Active Engage in Learning**
  - ✔ Memorize content
  - ✔ Work together
  - ✔ Build a strong web of inter connected information
  - ✔ Solve real world problems

Project-based Learning

- Project-based learning is an instructional approach where we learn by investigating a complex question, problem or challenge.
- It promotes **active learning, engages students, and allows for higher order thinking.**
- Students explore real-world problems and find answers through the completion of a project.
- Students also have some control over the project they will be working on, how the project will finish, as well as the end product.

Project-based Learning

- In project-based learning, teachers facilitate and guide students through the engineering design process, while students actively engage in research and problem solving activities within a team setting.
- The students need to produce **a solution to solve the problem** and are then required **to produce an outcome in the form of a report**.
- Teaching is considered as an input directing the learning process.
- The problem is open ended and the focus is on the application and assimilation of previously acquired knowledge.
- In a project, the **production of an end product is the focus of the students**.

Project-based Learning

- Involves
  - Knowledge
  - Critical thinking
  - Collaboration
  - Communication

Difference between Problem Based And Project Based Learning

PROBLEM BASED LEARNING

- Often share the outcomes and jointly set the learning goals and outcomes.
- More likely to be a single subject and shorter.
- Provides specific steps.
- Uses scenarios and cases that are perhaps less related to real life.

PROJECT BASED LEARNING

- Goals are set and quite structured.
- Often multidisciplinary and longer.
- Follows general steps.
- Incudes creation of a product or performance
- Involves authentic tasks that solve real- world problems.

- Similarities
  - Focus on open ended task or question
  - Provide authentic applications on content and skills
  - Emphasize student independence and inquiry
  - Longer and more multifaceted than traditional lessons and assignments

Project-based Learning and Problem-based Learning in Design

Similarities

Both PBLs:

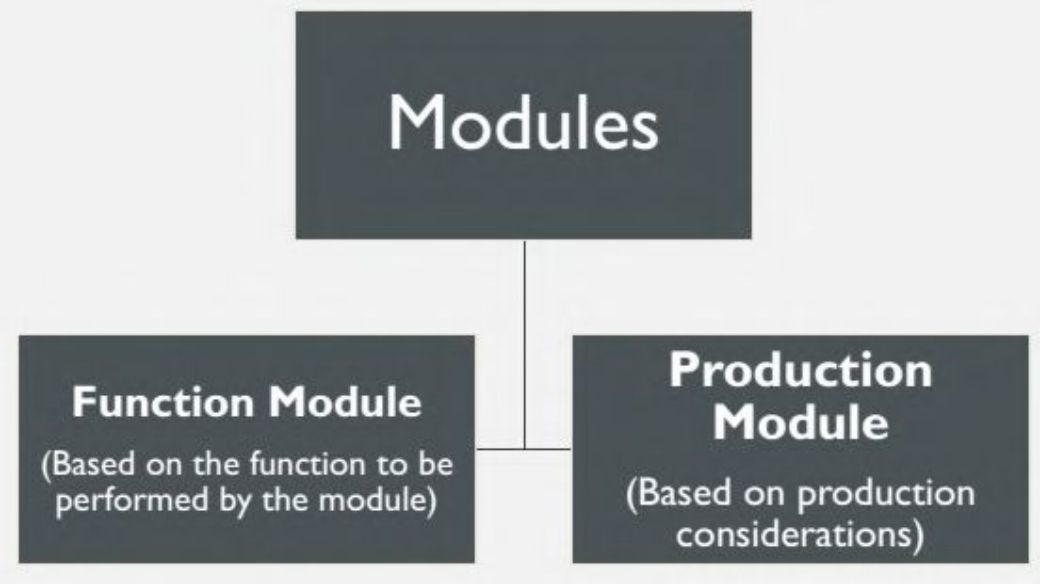
- Focus on an open-ended question or task
- Provide authentic applications of content and skills
- Build 21st century success skills
- Emphasize student independence and inquiry
- Are longer and more multifaceted than traditional lessons or assignments

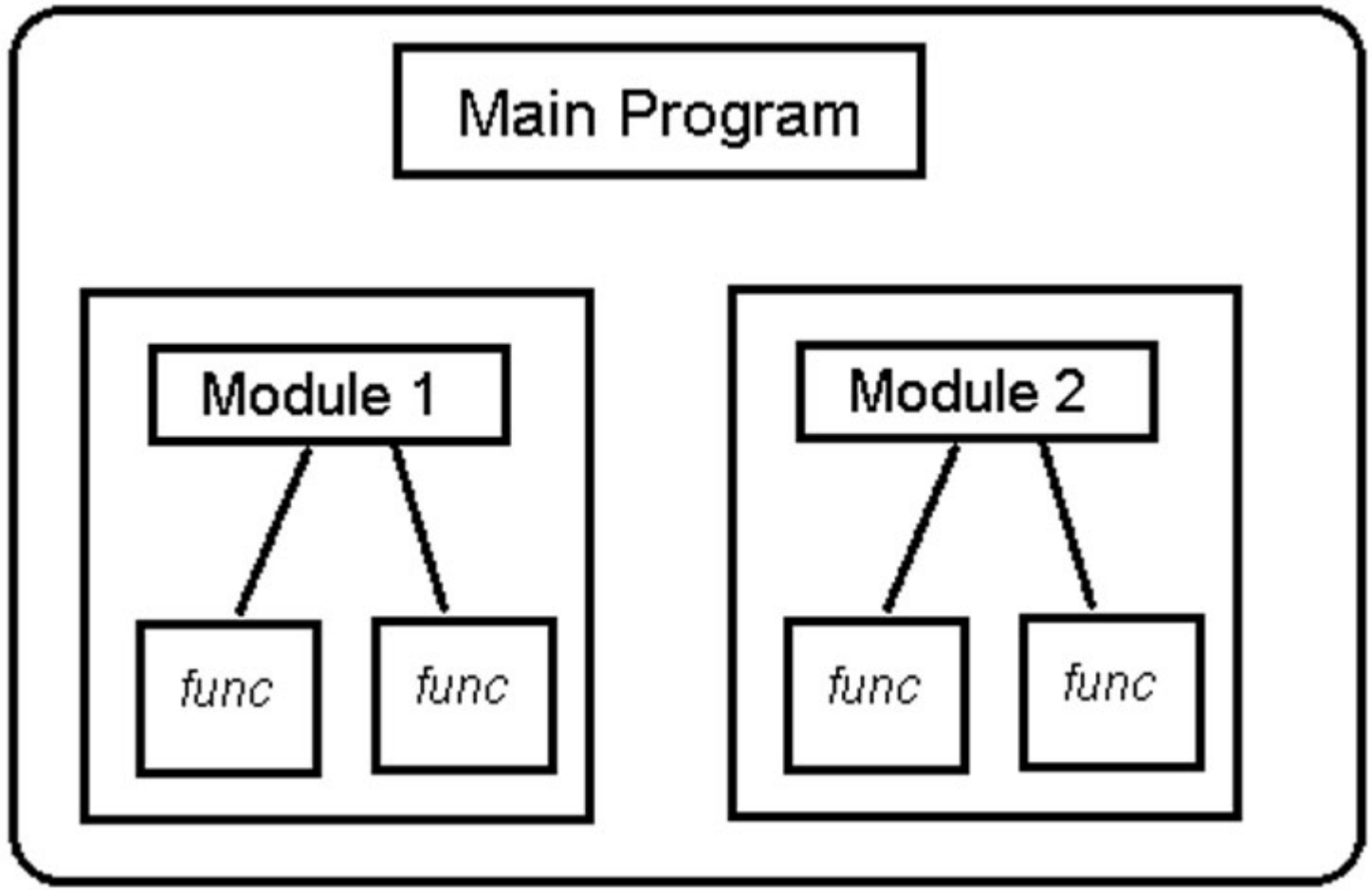
Differences	
Project Based Learning	**Problem Based Learning**
Often multi-subject	More often single-subject, but can be multi-subject
May be lengthy (weeks or months)	Tend to be shorter, but can be lengthy
Follows general, variously-named steps	Classically follows specific, traditionally prescribed steps
Includes the creation of a product or performance	The "product" may be tangible OR a proposed solution, expressed in writing or in a presentation
May use scenarios but often involves real-world, fully authentic tasks and settings	Often uses case studies or fictitious scenarios as "ill-structured problems"

Modular Design

- Module means separate elements
- Modular design is an approach in which a product is designed for assembling in module-wise fashion
- Modular products are the artefacts that are composed of many modules
- These modules function together to get the overall function of the product
- Modular products can be machines, assemblies and components that full various overall functions through the combination of distinct building blocks or modules
- In a modular product (or modular system), the overall function performed by the product is the results achieved through a combination of discrete units (modules)

- Dividing a product into discrete units based on some criteria is called as modularization of a product.
- Modular products or modular Systems are built up on separable or inseparable units called as modules
- The basic idea behind modular design is to organize a complex system as a set of distinct component that can be developed independently and then assembled together to perform a function.




Main Program
Module 1
func
func
Module 2
func
func

- Stages

1. Clarify the task
2. Establish function structure
3. Searching for solution principles and concept variants
4. Selecting and evaluating
5. Preparing design and dimensioned layouts
6. Preparing production document

1. Clarify the task
   - The function to be performed by each module is to be identified and stated clearly in this stage.
   - The contribution of the module to the overall function must also be clarified

2. Establish function structure
   - The function structure is very important in the development of modular system.
   - It is the splitting up of the required overall function into subfunctions
   - The reason for splitting up of modules must be established in this stage

3. Searching for solution principles and concept variants

- Next step is to find solution principles for the implementation of various sub functions.
- Designer should look for solution variants, which are not affecting the basic working principle and basic design.

4. Selecting and evaluating

- If several concept variants are evolved during the previous stage, each must be evaluated with the help of technical end economic criteria.
- The most favorable solution concepts needs to be selected.

5. Preparing design and dimensioned layouts

- Once a solution concept has been selected, the individual modules must be designed in accordance both with their function and production requirements.
- In the design of modular systems, production and assembly considerations are very important along with its economic importance.
- The design is then to be presented with complete details.

6. Preparing production document

- Production documents must be prepared in complete such a way that it can be executed without ambiguity.
- For this standards are to be followed for design communication.
- If possible , the communication can be in the form of computer aided documents

Modular Design

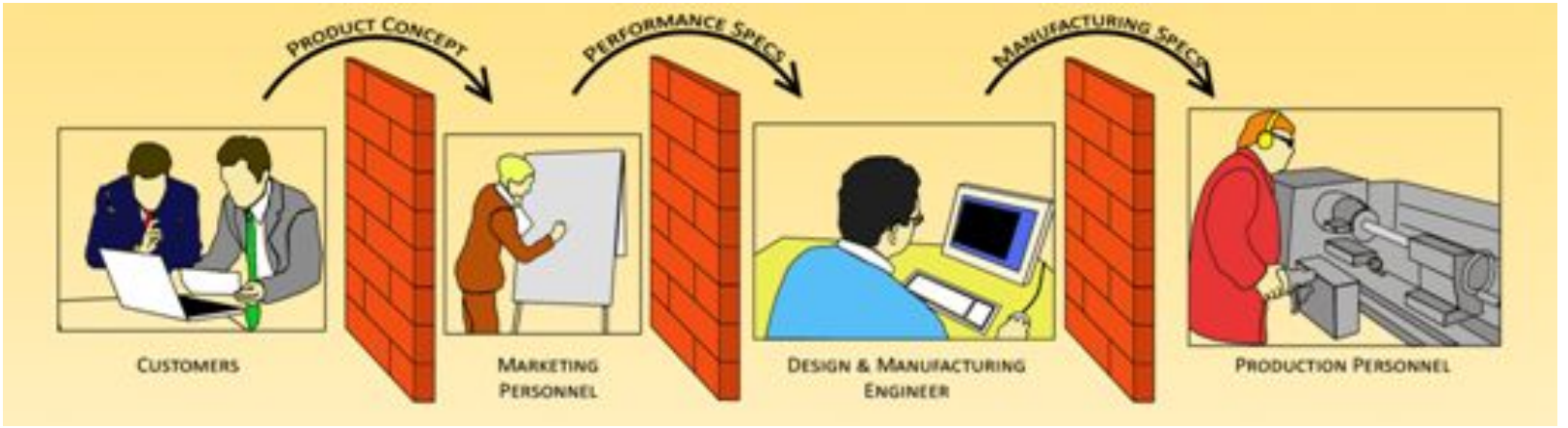
- ***Advantages***
  - Minimizing cost.
  - Design of a single part is easier as designer can concentrate only in one section.
  - Module can be separately improved without affecting the entire product
  - A part of module can be upgraded.
  - Replacement of a part become cheaper.
  - Shorten the design cycle.
  - Improves reliability and quality

Concurrent Engineering

- It is an approach in product design process in which people from various functional areas works together simultaneously to develop a product.
- This kind of engineering is also known as Simultaneous Engineering or Parallel Engineering.
- This approach is adopted to improve the efficiency of product design and reduce the product development cycle time.

Concurrent Engineering

Concurrent Engineering



Traditional Process = Linear

Vs

Concurrent Engineering = Team collaboration

Concurrent Engineering

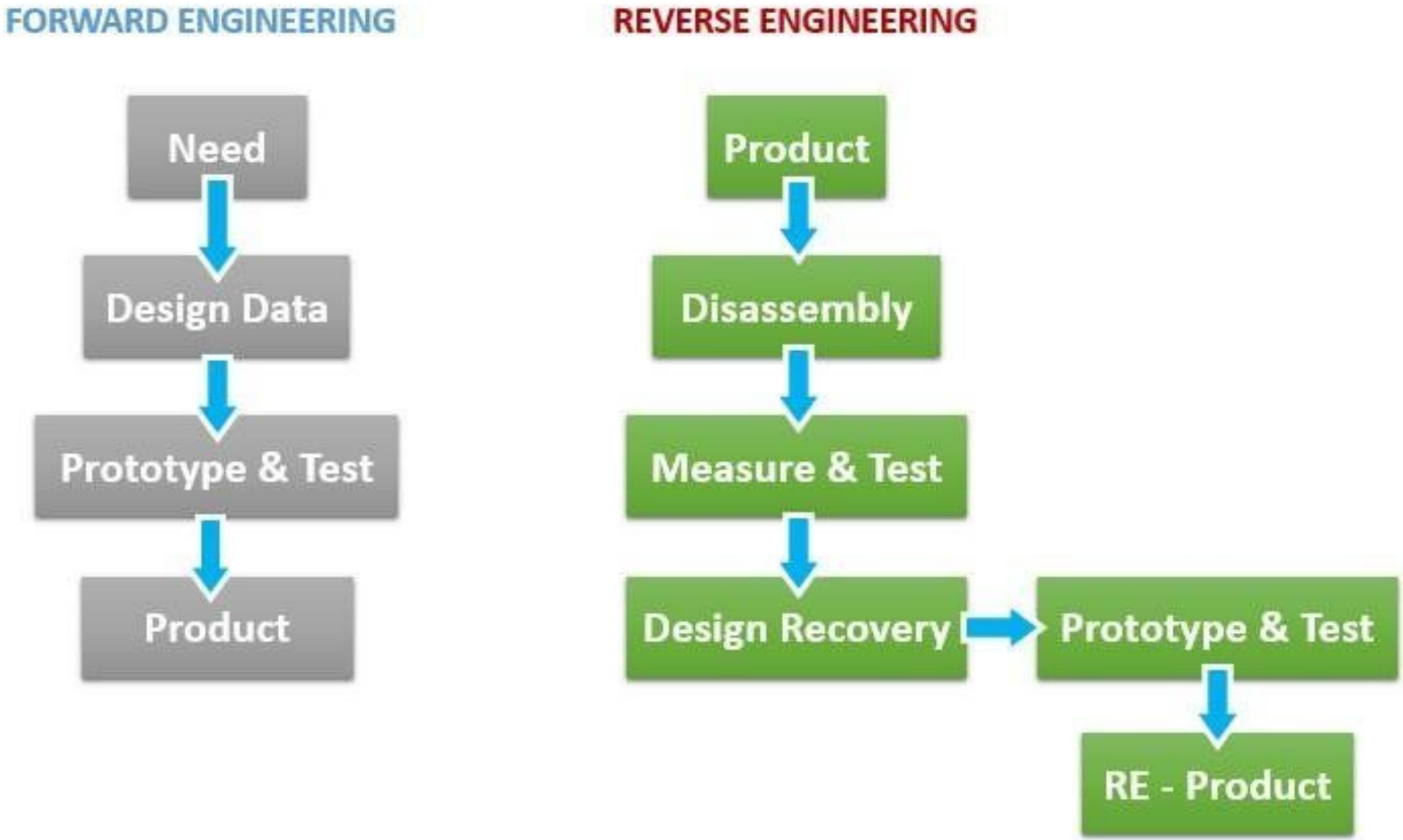
- **Advantages**
  - Reduce design time.
  - Reduce manufacturing cost.
  - It encourages multi-disciplinary collaboration
  - Enhanced quality
  - Reduces cost for design changes
  - Ensures correct data and information transfer between various sections
  - Simultaneous thinking leads to amazing innovations
  - Every person has the feel of belongingness to the product

Disadvantages

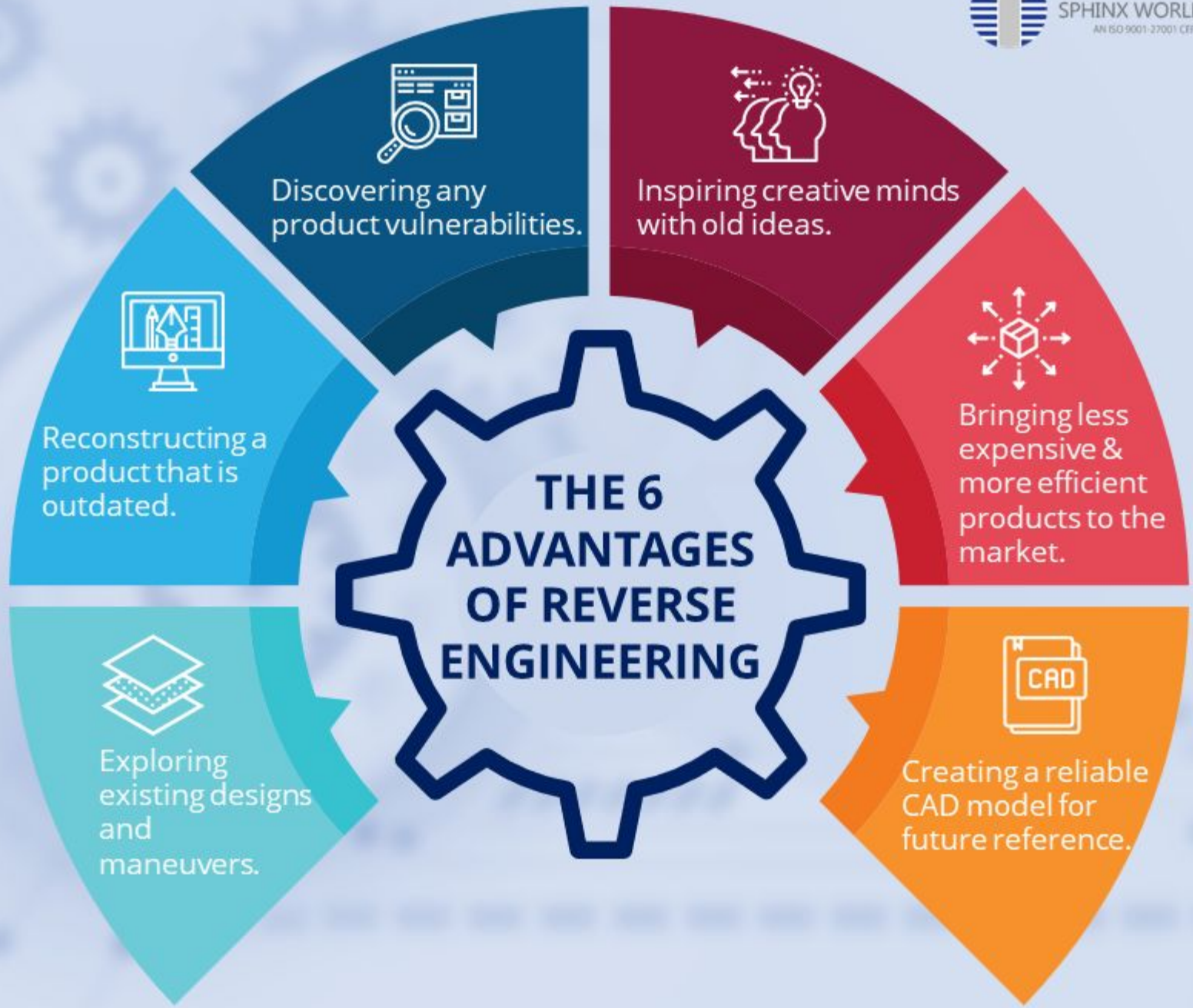
- Complex to manage
- Relies on everyone working together hence communication is critical

Reverse Engineering in Design

- Reverse Engineering is an approach in which an existing product is analyzed and another product is developed in light of the analysis.
- The product that is analyzed can be own product of the producer or a product from a competitor.
- In reverse engineering, a product is dissected or dis-assembled to find out in detail how a part works and why is it used. This information obtained by this process can then be applied to solve own design problem or develop a new product.
- Reverse Engineering is essentially a functional decomposition process in the reverse direction.
- An existing product is analyzed into subsystems, which are further analyzed into deep to ultimately establish the product concept
- This analysis will help the designer to identify weak side of the design
- It can further help to replace it or use another proven technology to improve the product.


FORWARD ENGINEERING
Need
Design Data
Prototype & Test
Product
REVERSE ENGINEERING
Product
Disassembly
Measure & Test
Design Recovery
Prototype & Test
RE - Product

SPHINX WORLDBIZ LIMITED
AN ISO 9001-27001 CERTIFIED COMPANY

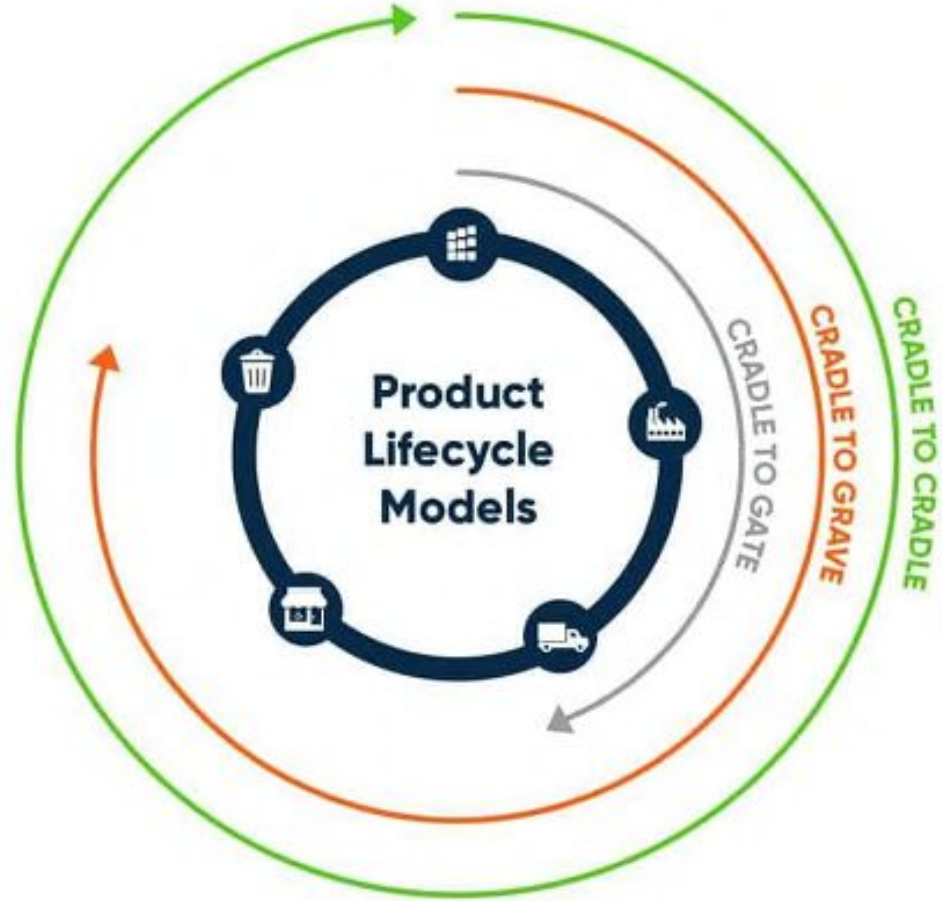


Life Cycle Design Approaches

- The application of the life cycle assessment concept to the design phase of the product development process is known as LCD.
- LCD is a design intervention which takes into consideration all the phases of a product's life cycle in the context of the entire design process, from concept definition to detailed design development
  - Development
  - Production
  - Distribution
  - Use
  - Maintenance
  - Disposal
  - Recovery

- The selection of design alternatives must be guided by considering the main factors of product success (design targets), in relation to all the phases of the life cycle:
  - Resources utilization (optimization of the materials and energy use)
  - Manufacturing planning (optimization of the production processes)
  - Life cycle cost (optimization of the total cost of life cycle)
  - Product properties (ease of production, functionality, safety, quality, reliability, aesthetics)
  - Company policies (respect for the common company position and objectives)
  - Environmental protection (control and minimization of environmental impacts).


RAW MATERIAL
WASTE
Product
Lifecycle
PROCESSING
RETAIL & USE PHASE
TRANSPORTATION

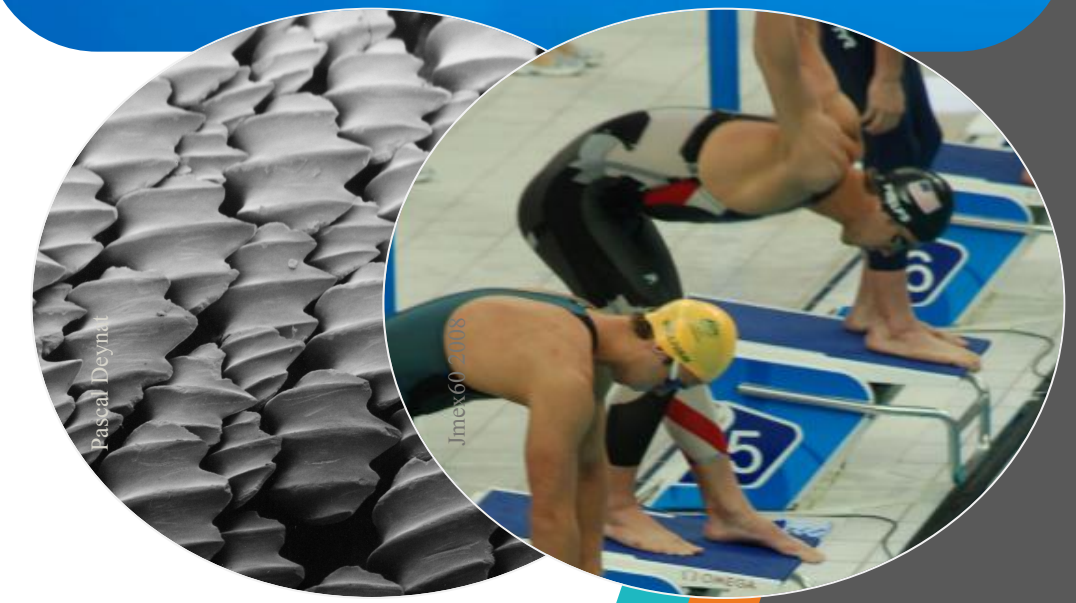

Product
Lifecycle
Models
CRADLE TO GATE
CRADLE TO GRAVE
CRADLE TO CRADLE

Application of Biomimicry

- “Biomimicry" borrows nature's blueprints, recipes, processes, and ecosystem strategies and then comes up with design principles to solve our own problems
- An approach to innovation that seeks sustainable solutions to human challenges by emulating natures patterns and strategies.

In Japan, a new commuter train was going so fast that it made a booming sound when it entered tunnels. Engineers successfully re-designed the nose of the train by copying the Kingfisher bird's beak shape and solved the noise problem.

Designers at Speedo were inspired by the mosaic-like layering of shark skin to create a swimsuit fabric that could reduce “drag” on the swimmer. Famously, these “Fastskin” suits were worn by the U.S. team at the 2008 Olympics and were later banned.



Ergonomics in Design

- Ergonomics is basically the science of analyzing work and then designing items (tools, equipment, products etc.) and methods to most appropriately fit the capabilities of the user
- Ergonomics design approach focuses on human comfort and decreased fatigue through product design.
- During the design phase of a product, all the aspects of the product that can cause discomfort while using that product are identified. Then, analyzes the causes of the discomfort and appropriate solutions will be incorporated in the product design.

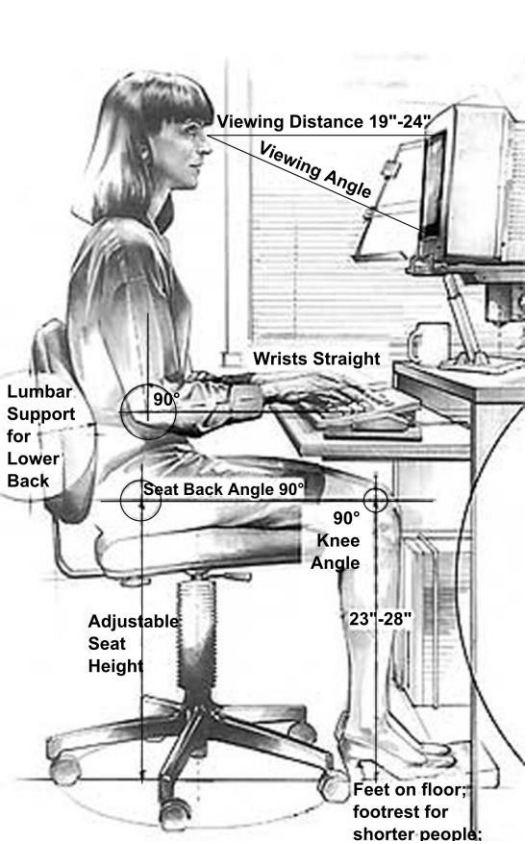
Ergonomics in Design

- Ergonomic design applied to an office chair will focus on how much it is comfortable for a Person who sits on it during office work.
- A chair ergonomically designed for dining purpose and a chair meant for relaxed sitting at beach will be different.
- It is, because, the kind of comfort and function to be provided by the chairs in these situations are different

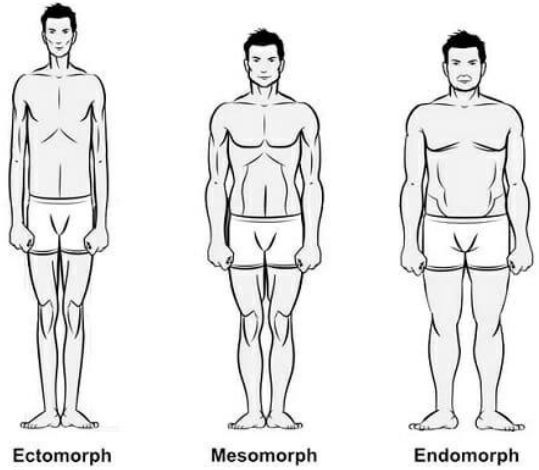
Factors Considered in Ergonomics Design

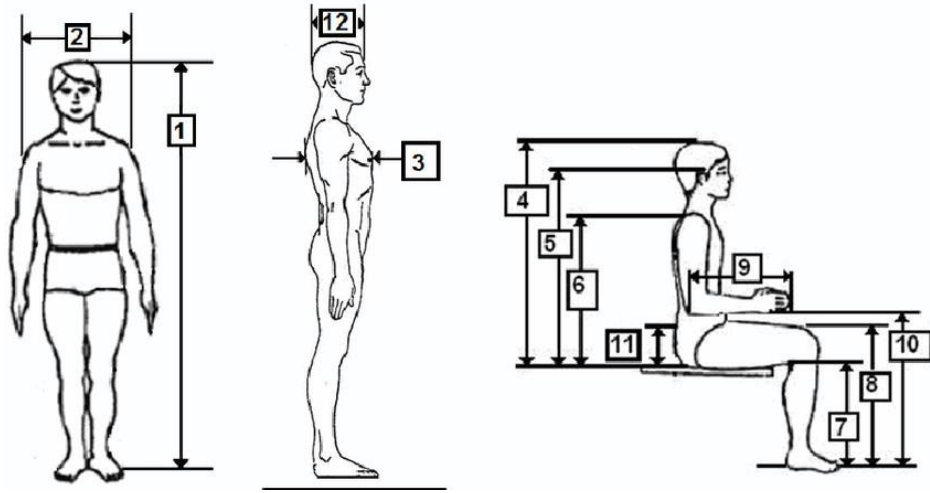
- To develop an ergonomic design (for a product or system), the designer will have to consider and analyse
  - Anthropometric data (dimensions of human body),
  - Posture of working while using the product,
  - Kind of movements and kind of workspace.
- Ultimately, ergonomic design involves every aspect of user-product interaction, for the comfortable utilization of a product.

ANTHROPOMETRY

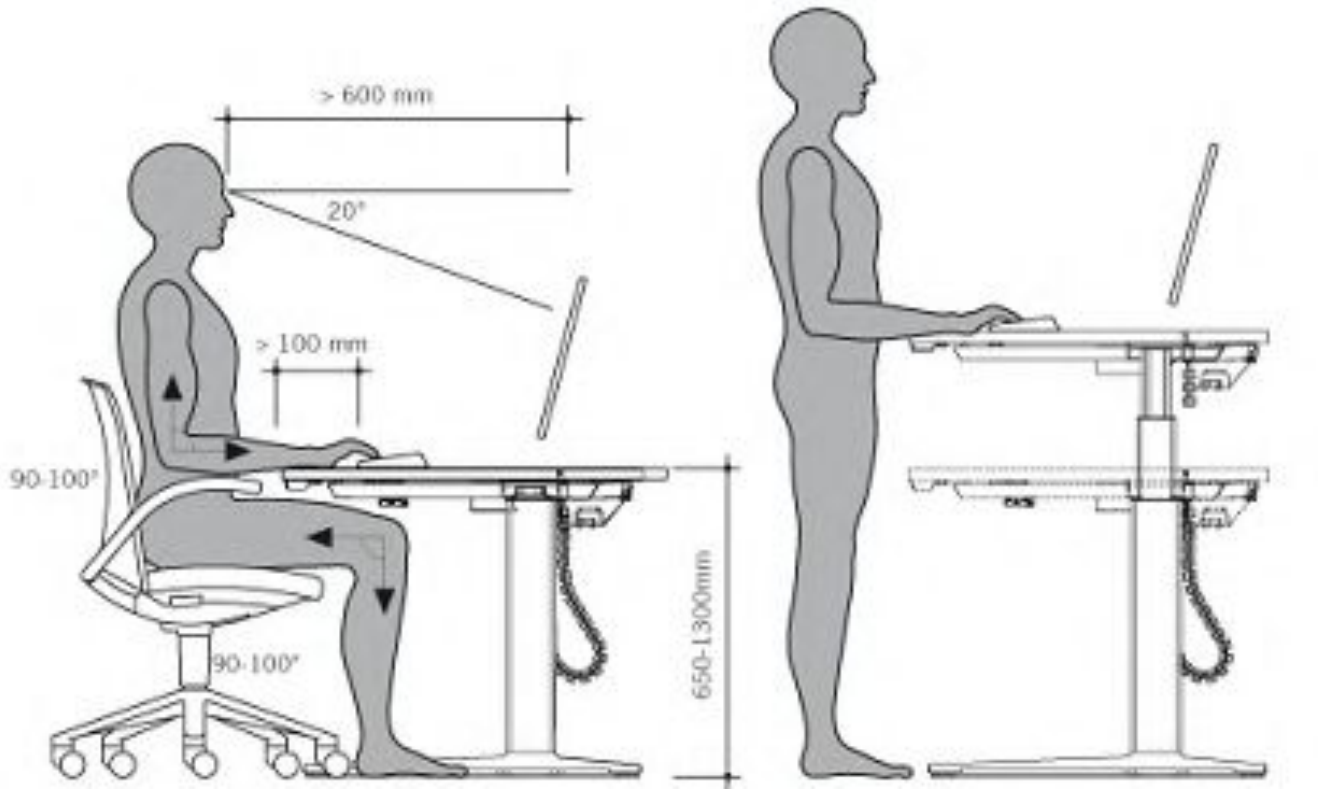


- Anthropometry is the science that measures the range of body sizes in a population.
- While designing products, it is very important for a designer to remember that people come in many sizes and shape.
- The anthropometric data vary considerably between human races.
- Age and occupation of the user is also relevant in anthropometric study.

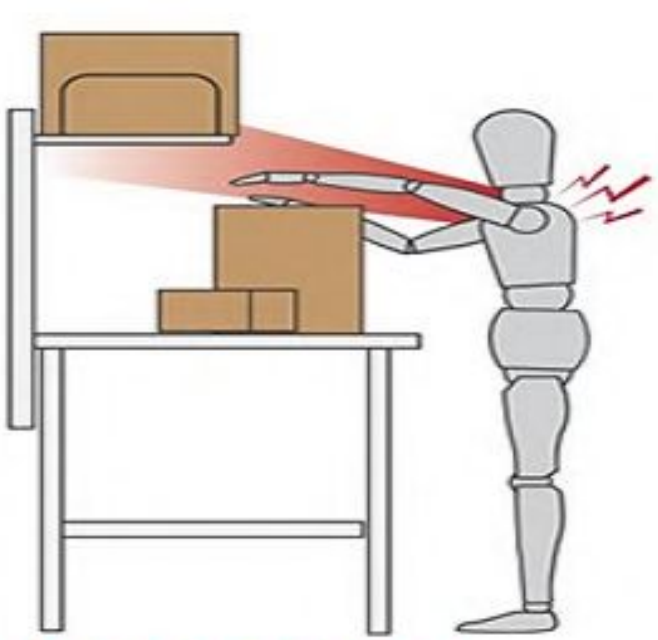




- Posture while using product
  - Standing, sitting, reaching, moving and combinations of these.



- Movements while using product



Danger Zone:
Reaching above the shoulder

Neutral Position:
Keep arms under shoulder height

- Kind of workspace

- ***Advantages***
  - Health issues can be solved.
  - Reduce medical expenditure.
  - Increase savings because of productive, sustainable and effective work environment

Aesthetics in Design

- The meaning of the word 'aesthetics' is sensory perception
- Aesthetics is the feel that a human being perceives.
- Humans have five basic senses: touch, sight, hearing, smell and taste
- When a person perceives a sense of pleasure through any of the senses while using a product, then we can say that the product is aesthetically appealing.
- An important aspects for business merits and acceptability.
- Example: a good food, nice perfume.

- In engineering design, many products are intentionally designed to generate a defined perception in potential customers
- Aesthetics of a product (that is how a customer feels about a product) is a very important aspect for its business merit and acceptability.
- This feel (or perception) enables the customer to distinguish and choose a product from similar products.
- Few examples for demarcation of perceptions are:

  hot and cold, smooth and rough, soft and hard,

  heavy and light, dark and bright, sweet and sour,

  loud and quiet, sharp and dull, spacious and congested, etc..

Aesthetics in Design

Value Engineering

- Value engineering is used to solve the problems, identifying and eliminate unwanted cost and improve function and quality.
- Systematic method of improving the value of a product that a project produces.
- It is used to analyze a service, system or product to determine the best way to manage the important functions while reducing the cost.
- Technique for improving the value of the product, project and process

- The term value defined as the ratio of function to cost.

$$V = P/C$$

V- Value

P- Performance/function

C – Cost

- Poor Value results from:-
  - Poor collaboration within the design group
  - Badly conceived design objectives
  - Wrong assumptions based on poor information
  - Fixation with previous design concepts
  - Failure to assess the challenge in design

Exercises

- Apply value engineering to a pen, and design a lightweight pen torch. Illustrate the solution using sketches.
- Ergonomically design a vegetable knife for your kitchen, consider gripping material, shape, safety and placement of knife.
- Show the development of a nature inspired design for a solar powered bus waiting shed beside a highway. Relate between natural and man-made designs. Use hand sketches to support your arguments.