exists. There are no "dumb" ideas. The unworkable solutions will be evaluated and thrown out later.

3. **Stress the importance of quantity:** The group is encouraged to generate as many ideas as possible. As the number of ideas increases, so does the probability that really good ideas will surface.
4. **Build on and combine old ideas:** Brainstorm ways that existing solutions can be modified or combined into a new solution.
5. **Record everything said for later evaluation:** One person in the group is the designated record keeper. That one person writes down quick sketches of all ideas. These sketches will be reviewed and refined at a later stage in the design process by making ***affinity diagram***. An affinity diagram is a tool that gathers large amount of information and organise them into grouping based on their natural relationship. In it similar ideas or related items are grouped together.

Sketchstorming is the engineer's response to brainstorming. Sketchstorming is the visual creation and recording of ideas. Since solutions to engineering problems typically come in visual rather than verbal images, it is important to record these ideas onto paper in sketch form. Sketches are not detailed drawing of our ideas. They are quick, two-dimensional representations of what our mind is seeing. Sketching ideas quickly on paper allows us to store the visual image, modify the idea, and add details to the design later.

1.3.4 Step 4: Analyze and Select a Solution

Once we have conceived alternative solutions to our design problem, we need to analyze those solutions and then decide which solution is best suited for implementation. At this step in the design process, we must consider the results of our design analysis. This is highly subjective step and should be made by a group of experienced people. This section introduces a ***systematic methodology*** we can use to evaluate alternative designs and assist in making a decision.

(a) Analysis of Design Solutions

Before deciding which design solution to implement, we need to analyse each alternative solution against the selection criteria or specifications defined in step 1. We should perform several types of analysis on each design.

(i) Functional analysis
(ii) Ergonomics
(iii) Product safety and liability
(iv) Economic and market analysis
(v) Strength and mechanical analysis
(vi) Life cycle analysis

(i) **Functional analysis:** determines whether the given design solution will function the way it should. Functional analysis is fundamental to the evaluation and success of all design. A design solution that does not function properly is a failure even if it meets all other criteria. Economy, appearance, durability, and marketability of a design are unimportant if the product does not function properly.

(ii) **Ergonomics:** Ergonomics is the human factor in engineering. It is the study of how people interact with machines. Most products have to work with people in some manner. People occupy a space in or around the design and they may provide a source of power or control or act as a sensor for the design. A design solution can be considered successful if the design fits the people using it. The handle of a power tool must fit the hand of everybody using it. The geometric properties of people – their weight, height, reach, circumference, and so on- are called ***anthropometric data***. The difficulty in designing for ergonomics is the abundance of anthropometric data.

(iii) **Product safety and liability:** Because litigation has become common in today's environment, design engineers must be familiar with the issues of safety and liability. Liability refers to the manufacturer of a machine or product being liable, or financially responsible, for any injury or damage resulting from the use of an unsafe product. The primary consideration for safety in product design is to assure that the use of the design does not cause injury to humans. Safety and product liability issues, however, can also extend beyond human injury to include property damage and environmental damage from the use of the design.

> Production are designed to maintenance safe and clean environment. This is called green designs.

The only way to assure that the design will not cause injury or loss is to design safety into the product. Design of a safe product is done in three

When redesign is achieved by changing some of the design parameters, it is often called *variant design*. *e.g. Samsung Smart Phone S-8* has been developed after changing the design parameter of S-7.

1.1.4 Selection Design

In this case the design task consists of selecting the components with the needed performance, quality, and cost from the catalogue of potential vendors. e.g., in a car manufacturing, few standard components (spark plug, battery, head light etc.) of a car are supplied by some other potential designers/vendors and in such a case these components are selected with the help of available potential designers/vendors catalogue.

1.1.5 Industrial Design (Aesthetic design)

This form of design deals with improving the visual appeal of a product to the human senses. Industrial design encompasses the consideration of how the human user can best interface with the product.

1.1.6 Evolutionary Design

Adaptive design and redesign can be combindly called evolutionary design. Evolutionary design involves competitor analysis, benchmarking and reverse engineering.

- *Competitor analysis* involves lining up competitors side-by-side and highlighting similarity and differences. It results in strategy document that helps define the general direction for design without defining the design itself.
- ***Benchmarking*** is a process for measuring a company's operations against the best practices of companies both inside and outside of their industry. It is a way to learn from other businesses through an exchange of information. Benchmarking operates most effectively on a quid pro quo basis - as an exchange of information between companies that are not direct competitors but can learn from each other's business operations. Benchmarking measures the concepts of 'best-in-class' organisations, determines how the best in class achieve those concepts and uses that information as the basis for new idea generation and breakthrough design. Design of Delhi Metro is bench mark for design of Metro in another cities of India.
- ***Reverse engineering*** is the process of decomposing an existing solution to