# Inventions and Inovations

## UNIT TWO READING ASSINGMENT...

**The Attributes of Design**

- Purposeful
- Has Requirements
- Systematic
- Iterative
- Creative
- Multiple Solutions

**Purposeful** – The design process must have a purpose or it is simply not technological design or engineering design. The purpose of te4chnological design is obvious, the designer is trying to solve a problem, meet a need, or develop a new product.

**Requirement** – requirements consist of two parts. Part one spells out what the solutions must do, in other words are the specifications. For example: a new vehicle must carry six passengers, get at least 25 miles to the gallon, meet emission requirements and so on. The second part spells out the limitations, or constraints. For example: The vehicle must be in the showroom within 10 months, use 90% of parts common to other vehicles, cost less than $12,000 to produce, and use no hazardous materials etc. As one can see, there could be an overlap between specifications and constraints. A simple design brief might have a blanket category called "requirements".

**Technological design must be systematic** – other types of design might not require a systematic, very deliberate approach, but technological design demands it. One of the greatest technological disasters of all time, at least in terms of national prestige, was the explosion of the space shuttle Challenger in 1986. There were many problems in the decision making process which led up to the disaster, but one in particular stands out. Because Congress funded the project at a level far below estimates, NASA decided to leave behind design procedures which had been proven over the decades. The procedure was this: design, build, test, redesign, rebuild and retest all major subsystems such as engines, boosters, tanks, the body, computers and so on. At this point the entire system is redesigned to accommodate what has been learned. Then, and only then, would the entire assembly be ready for assembly and final testing. To save money and time, NASA decided on an "all up" approach (Pinkus, 1997, pp.91-170). In other words, all major components were designed assembled and tested as a complete shuttle system. By omitting the more lengthy design procedure, many flaws remained buried and unexamined in this case until too late. This is a bit of an oversimplification but violation of a systematic design procedure, proven over decades was a contributing factor.

**Technological design must be iterative** -Iterative simply means repetitive, but the concept

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is closely tied to the concept of being systematic. Perhaps some examples will help sort out the meaning. In our personal experience many of us have designed technological solutions that were far from satisfactory, but we didn't take the time to go back and redesign, rebuild or correct the problem. The solution could have been something simple like a doghouse. We made the entry hole too small, and six months later, the growing pup could not enter without great difficulty. Oh well, he would rather sleep outside anyway. We get bored after the first try, and would rather move on to something else rather than re-design and produce a truly elegant and useful solution.

One level up on the scale of satisfactory "iterative" design process is found the housing industry. We know that the more iterations a design has been through, the more satisfactory the design becomes. A good example of the iterative process would be manufactured housing. But, sometimes other factors get in the way, such as a pre existing attitude like: "All manufactured homes are just cheap trailer houses." In contrast, we could think of it as selecting a design that has been built thousands of times, owners have been surveyed to determine what the problems were, and the design altered as a result.

A second level up in the design iteration is found in the auto industry. Automobiles are built by millions, and if automakers used all their design experience to improve the next model, we would truly have some excellent cars. But, factors such as style force changes that often make for less satisfactory designs that result in rattles, leaks, inefficiency and breakdowns. Once again, attitudes of a public not familiar with the design process influence the actions of the manufacturer.

**Creativity** -The ability to design solutions to problems as mentioned in unit 1 has even been defined as intelligence. Howard Gardner defines intelligence as "the capacity to solve problems or to fashion products that are valued in one or more cultural settings"(Garder and Hatch, 1990). Though the term "thinking out of the box" is often overused, a properly crafted design activity call forth exactly this kind of thinking. Much, if not most design today is done by interdisciplinary teams.

## There are at least three reasons:

1. **Brainstorming is more effective in a group setting**
2. **Different expertise can be called upon to solve different parts of the problem as they are identified.**
3. **Each discipline thinks with a certain pattern.**

Someone from "outside" a given discipline or field may see solutions that escape the experts who were only "allowed" to think as they had been trained.

Multiple solutions. Any technological design activity must allow for, indeed demand multiple solutions. Perhaps the methods used in solving mathematics problems cause us to

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think that there is only one correct solution to a problem. In mathematics, that is often true. Call it lazy, call it attention span, call it fast paced society, but we all seem to be conditioned to find the right answer or an acceptable answer and move on. This is a tendency that must be counteracted vigorously in seeking technological design solutions or designs will suffer. If there were only one "correct" way to design airplanes, we would still be using the Wright Brothers design. A field is never so mature that there is a "best" way to do something. For example, the Stirling engine, designed in 1816, was discarded by the early 1900's as hopelessly inefficient. Today thanks to modern materials science and engineering, it is a most promising engine of the future (Nice, n.d.).

## What is Engineering Design?

Engineering design and technological design are terms that are often used interchangeably in literature. It describes a process for designing solutions to technological or engineering problems. There are similar terms such as industrial design or architectural design or interior design which are more often used to describe a career in certain areas rather than a generic process. To bring the concept of the industrial designer we might look at the products of Apple Computer. When IBM and hundreds of clone makers were making computers in plain gray boxes, Apple was making the shapely and "sexy" all-in-one MacIntosh. Though marketing blunders brought Apple to the edge of bankruptcy several times, they managed to escape disaster one more time by introducing the shapely and colorful IMAC. It did not represent a technological breakthrough, but it looked great and sold phenomenally well.

Engineering design is not a career, but a process used to design solutions to technological problems. Following is a list of the essentials steps found in the design process. They do not have to be performed in an exact order and may be condensed somewhat depending on the complexity of the design problem.

1. **Identify the problem**
2. **Define or "refine" the problem.**
3. **Gather information**
4. **Develop alternate solutions (first idea is rarely the best)**
5. **Select and refine the best solution**
6. **Express the design solution (a sketch or drawing)**
7. **Build a model or prototype of the solution**
8. **Evaluate, revise and refine the solution**
9. **Communicate the solution**

When developing an understanding of problem solving, there are various elements that play an important part in completing the solution.

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**Troubleshooting** – is most often thought of as technical work, falling into the workload of the technician rather than that of the designer, technologist or engineer. But there are many times we must "troubleshoot" the design in order to get it to work satisfactorily. One of the reasons that we sometimes overlook troubleshooting in the design process is that many have a preconceived notion that science-technology-technical form a continuum from theoretical to practical. The scientist discovers knowledge about nature, the engineer or technologist or designer apply this knowledge to create new products, and the technician builds, assembles and repairs (troubleshoots) the products. This concept is useful in understanding the various careers and disciplines and we should understand that distinctions between scientists, engineers and technicians are not always rigid and crisply defined. When a design is first expressed in the form of a sketch or drawing, none of its flaws may be apparent. Many problems will surface when a working prototype is built. More problems will surface when the product is mass produced, since the design may only function if all components are well within tolerance. A design flaw could be buried so deeply that it may not surface until the product as been used for thousands of hours.

Troubleshooting must be encouraged as necessary in the design process or successful solutions may not be plentiful. Sometimes the principal designer may not have the knowledge to troubleshoot the interactions of all the subsystems. This is another reason that teamwork is encouraged in design activities. The need to "troubleshoot" reinforces the distinction between the old individual project approach and the new design approach

**Research and Development** – refers to the need to refine one or more aspects of a design to ready it for production. For example, a software product designed for accountants might function beautifully, but the user interface might be confusing, awkward or just visually ugly. This would call for research and development on the interface. Another example might be a hand held or pocket computer. It may meet all design specifications, but test users complain its just too heavy for comfort, and even though they like it, they would not buy it.

**Experimentation** - Research and development might require experimentation, or it might be necessary before the prototype can be made to function. Experimentation is a process often used in science and involves testing under controlled conditions. To use an example from the classroom, it could be that a prototype has failed consistently due to the heat generated by an electric motor. The motor can only be held in place by an adhesive for a variety of reasons. So, a team of students might be assigned to gather and test as many adhesives as are available. Over two dozen might adhesives might have to be tested under controlled conditions to find the best one.

## Design in Various Fields:

**Medical Technology**
Technological advances in medicine have had a tremendous effect on our quality of life.

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When we think of medical technology, most often x-ray machines, rehab equipment, lasers and other physical hardware comes to mind. Medical technology involves much more than just tools or hardware; it involves genetics, prosthetics, pharmaceuticals, procedures, software and many other "hidden" or less obvious materials. Technological design makes it possible for the medical field to continue improving healthcare world wide.

**Agriculture and Bio Related Technology**

Agriculture and Bio Related Technology is no less controversial than any other technology. Technological developments that negatively affect the environment and the feed we consume can have devastating effects. Fertilizers and pesticides are designed to increase production of crops in order to supply growing populations but they also have negative aspects such as polluting water supplies, altering eco systems, and killing other plants and animals. The design process is supposed to consider all positive and negative consequences but, it is the unintended consequences that may cause problems in the future that cannot be changed.

**Design in Energy and Power Technology**

We have made significant progress in the design and development of new energy and power systems. Our society's reliance on fossil fuels has made the development of alternate energy difficult. Although technology has made it possible to create power from wind, water and the sun, we are unable to meet the needs with just alternative forms of energy. Designers are constantly developing new technology that will help meet the demand for energy but, we also have to learn how to use energy more efficiently. We have become used to a way of life that many would consider wasteful and inefficient. Today we are designing automobiles that use electricity generated by fuel cells, wind turbines are being constructed all over the nation, and other significant advances have been made in energy and power technology.

**Design in Information and Communication Technology**

Communication technology is one area where the ability to change and improve in a very short amount of time is required to meet the demand. If you look at the computer industry as an example, functionality and performance are continuously being improved. Newer, faster, more functional operating systems and hardware are introduced daily. The internet and wireless communication have made is possible to distribute information anywhere in the world and even into space. The technology developed over the last ten years has made it possible for a person to work in one part of the country and live somewhere else.

Greater access to information also has negative consequences. Information can be accessed that is confidential or classified. Computer viruses are being written that will disrupt work flow and can even render entire networks useless.

**Design in Transportation Technology**

Transportation technology is dependent on many of the other areas of technology to make it

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run more efficiently. Communication, manufacturing and construction technology produce many of the products and systems necessary for transportation. All of these areas working together create a transportation systems. Designers have to consider how the technology they are creating will work within the system. The products we use every day are distributed by different forms of transportation such as; aircraft, ships, trains and trucks. The network of vehicles makes it possible for us to ship good throughout the U.S. and even the world in as little as 24 hours.

**Design in Manufacturing Technology**

Manufacturing technology is also an area that has experienced significant change when it comes to the design process. New synthetic materials are being developed to replace some of the raw materials were once required to create products. The introduction of synthetic materials has also given us the ability to design products that we were previously unable to make. Sometimes synthetic materials are combined with organic materials to create composites that are cheaper and easier to use than organic materials. Organic materials have to be harvested and processed before they can be used. Computer controlled equipment and robotics have also had an impact on the manufacturing industry. Through the use of computers, we are able to increase production and quality by monitoring the assembly line and machining precision parts.

**Design in Construction Technology**

Design in the construction world is mainly architects and engineers. In commercial construction, engineers are challenged to push the limits of construction for lower costs. This requires them to analyze every aspect of structures to determine strengths, weakness and overall cost. In addition, climate, appearance, style and building codes will determine the final design. Engineers must take into account many factors that will affect the final design of the construction of a building

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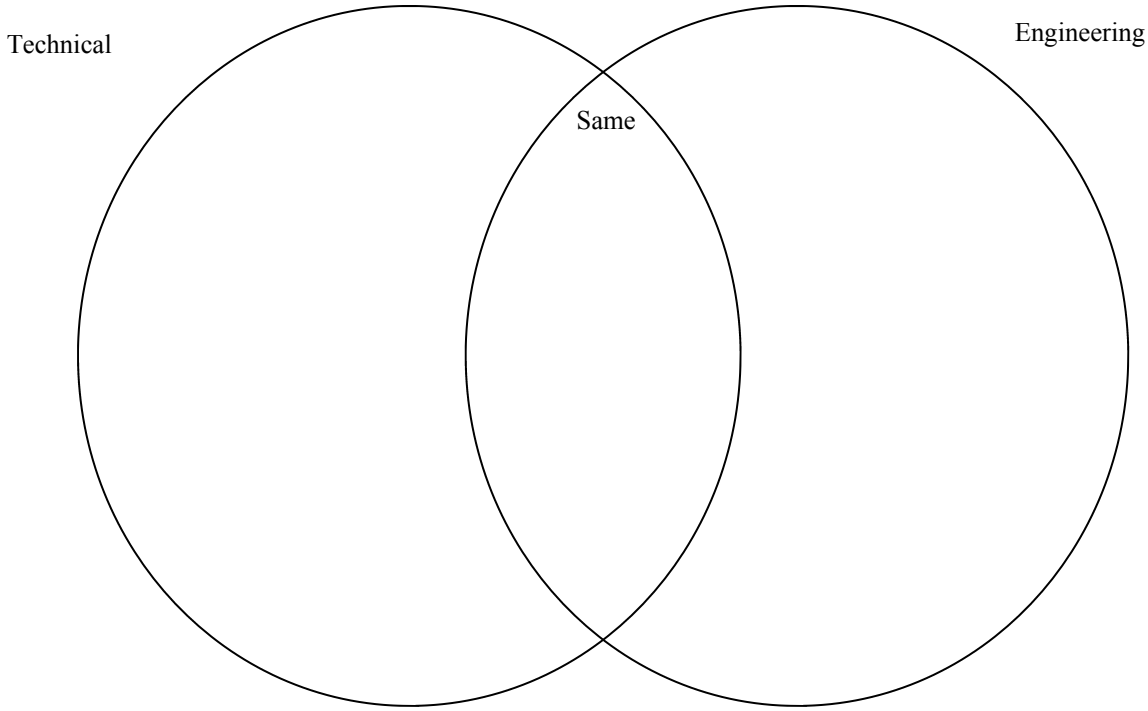
# Inventions and Innovations Unit 2 Worksheet

Using this worksheet, in the Venn Diagram, compare and contrast Technological Design and Engineering Design.

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