Applying the Design Process

Foundations of Technology,
Montgomery County Public Schools

Outcomes

In this presentation you will learn…

- Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. (ITEA 11-O)

- Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. (ITEA 11-P)

- Develop and produce a product or system using a design process (ITEA 11-Q)

- Evaluate final solutions and communicate observations, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. (ITEA 11-R)

Conceptual, Physical, and Mathematical Models

In working with the design process at the high school level, you will be applying many of the abilities that you learned in earlier grades. You will realize that not all problems can or should be solved. You will become more adept at identifying requirements in the design process.

These solutions started in the designers' minds, and then the designers recorded them on paper. They developed rough, refined, and detailed sketches. These sketches contained design ideas, not product plans. At some point the designers had to change two-dimensional drawings into three-dimensional models that could be evaluated.

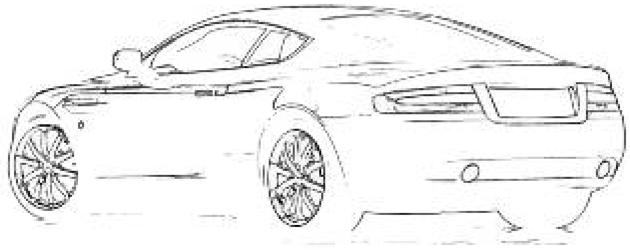
We use the products of technology everyday. Each product started with a problem or an opportunity that could be defined. Then, designers were challenged to solve this problem or meet the opportunity. They explored various ideas and developed solutions.

Use of Models in the Design Process

The conversion from drawings to models is essential to the design process. Everyone is familiar with models. Kids as well as adults play with model cars, trains, and other artifacts. They build towns and cities out of wooden blocks, cardboard, and other materials. They pretend that they are dealing with real-life situations.

Museums use models to show how things worked in the past. These models show a slice of historical life so we can better understand the present day.

This activity of imitating reality is widely used in product and system design. People simulate expected conditions to test their design ideas. This process is called **modeling** or **simulation**.



Sketch drawing of a sports car

Sports car model

Modeling

Simply stated, **modeling** is the activity of simulating actual events, structures, or conditions. For example, architects may build a model of a building to show clients how it will look.

Architects may use structural models to test a building's ability to withstand an earthquake and the forces of the wind. A model allows us to reduce complex mechanisms and events into an easily understood form.

All models can be grouped into three types:

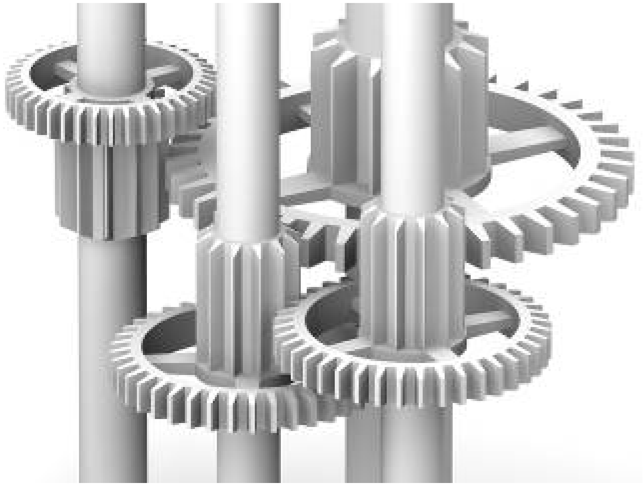
- **Graphic models**
- **Mathematical models**
- **Physical models**

Typical graphic models are conceptual drawings, graphs, charts, and diagrams.

corporate buildings in perspective made in 3d

Conceptual Models

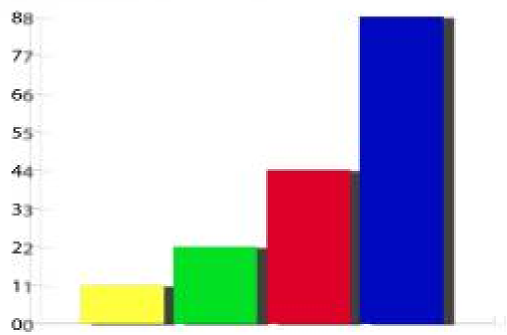
Conceptual models capture the designer's ideas for specific structures and products. They show a general view of the components and their relationships.



This conceptual model shows a designer's idea for gears in a mechanism.

Mathematical Models

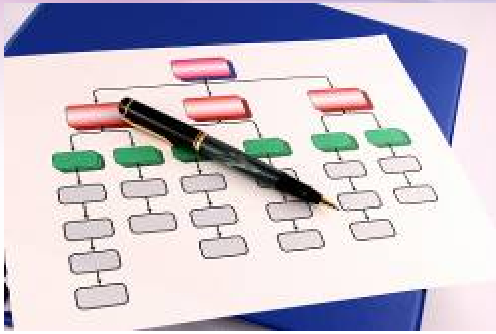
Graphs allow designers to organize and plot data. Graphs display numerical information that can be used to design products and assess testing results.



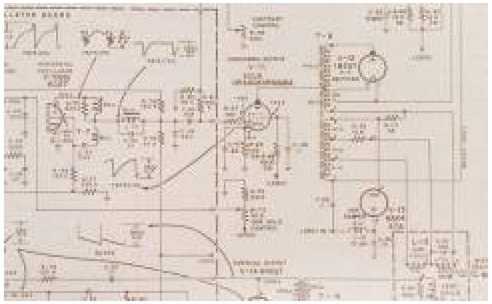
For example, a graph can be developed that shows speed and braking distance for different kinds of brakes. This information will help designers select the type of braking system to be used in a specific vehicle. This type of data can be shown on a line graph, a bar graph, or a pie chart.

Charts and Diagrams as Models

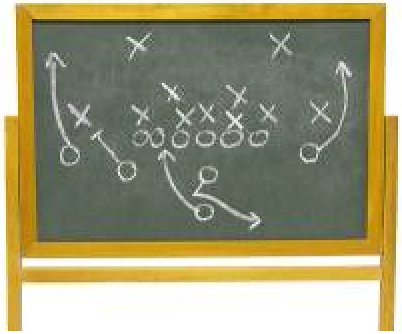
Charts show the relationship between people, actions, or operations. They are useful in selecting and sequencing tasks needed to complete a job. Various charts are used for specific tasks.



Diagrams show the relationship between components in a system. A schematic diagram can be used to indicate components in an electrical, mechanical, or fluid (hydraulic or pneumatic systems).



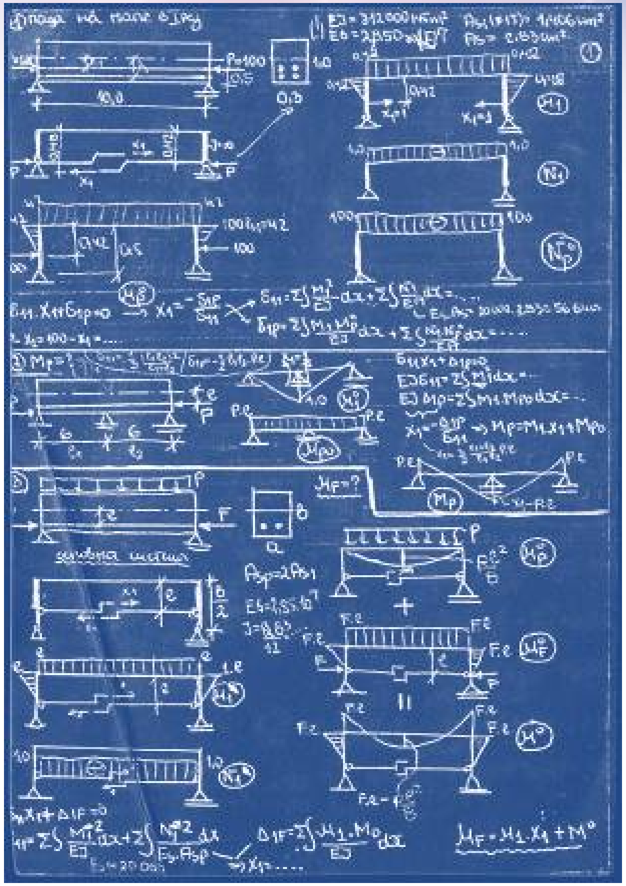
Another type of diagram with which many people are familiar is a play diagram. For example, football coaches develop them to show how players (components) should interact during an offensive or defensive play (system).



Complex Mathematical Models

The examples given so far are for simple mathematical models. Individuals use more complex models with thousands of formulas to predict the results of complex relationships.

For example, these formulas can be part of economic models that predict the economic growth for a period of time. Also, complex mathematical models track storms and space flights, predict ocean currents and land erosion, and help scientists conduct complex experiments.



Blueprints of physical science graphics and formulas

Physical Models: Mock-ups

Physical models are three-dimensional representations of reality. Two types of physical models exists: mock-ups and prototypes.

The first type of physical model is designed to show people how a product or structure will look. This type of model is an appearance model or **mock-up**. It is used to evaluate the styling, balance, color, or other aesthetic feature of a technology artifact.

Mock-ups are generally constructed of materials that are easy to work with. Commonly these materials include wood, clay, Styrofoam, paper, and various kinds of cardboard.

Cardboard house mock-up (model) on architect's plans

Physical Model: Prototype

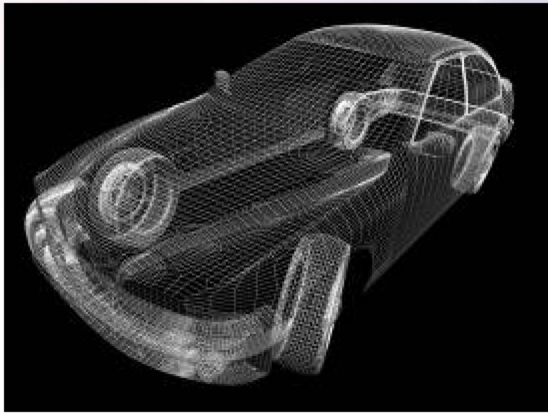
The second type of physical model is a **prototype**. A prototype is a working model of a system, assembly, or a product. Prototypes are built to test the operation, maintenance, and/or safety of the item. They are generally built of the same material as the final product.

It would be impractical to make a prototype of a skyscraper to full scale. Prototypes and other models should be used to test and evaluate the solutions.

Prototype models of corporate buildings

Wire Frame Models

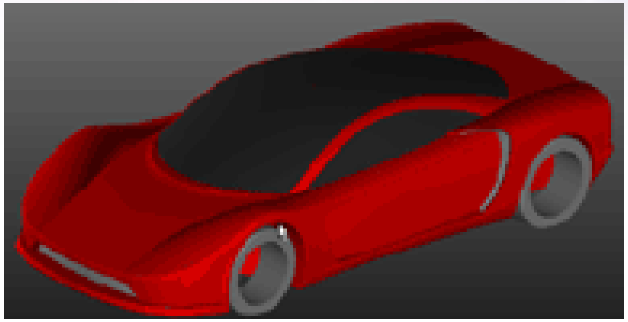
Computers have affected the way we work with models. Computers can be used to develop three types of three-dimensional models: wire frame, surface, and solid.



The **wire frame model** is developed by connecting all the edges of the object. The process produces a structure made up of straight and curved line.

Surface Models

Surface models can be thought of as a wire frame with a sheet of plastic drawn over it. Surface models show how the product will appear to the observer. Surface models can be colored to test the effects of color on the product’s appearance and acceptance.

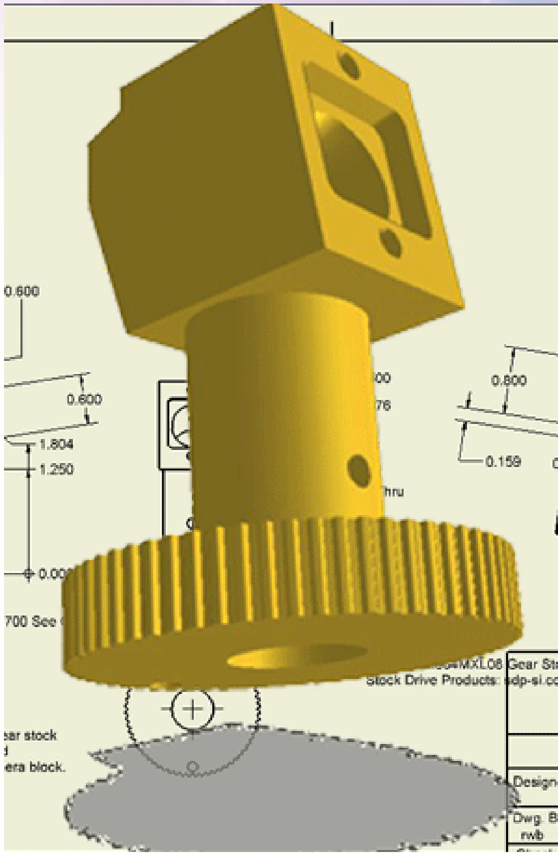


Surface models are widely used in developing sheet metal products. The surface model is first developed. Then the computer unfolds the model to produce a cutting pattern for the metal.

Solid Models

A **solid model** is the most complex of these models. Solid models look like surface models except the computer "thinks" of them as solids. This allows the designer to direct the computer to cut away parts, insert bolts and valves, and rotate moving parts, for example.

Solid models can be used to establish fits for mating parts and to set up the procedures needed to assemble parts into products.



Use of Models to Evaluate Design

Designers develop product ideas to meet human needs and wants. These designs must be evaluated. Evaluation requires that graphic, mathematical, or physical models be built. The models allow designers to study and refine specific mechanisms and the total product.

The completed model is subject to careful analysis. Designers and decisions makers evaluate its function, specifications, ergonomic qualities, market acceptance, and economic qualities. This is not the end of the design process, however.

These individuals address shortcomings in the design through redesign activities. Finally, an acceptable design emerges.

Analyzing the Design

Modeling helps the designers and decisions makers enter an important design activity: design analysis. This stage requires people to evaluate a design carefully in terms of such criteria as its purpose and its likely acceptance in the marketplace. This lesson will guide you through the evaluation process of analyzing the design and how an acceptable design emerges.

The evaluation process helps designers and decision makers to choose the best design. The five types of design analysis usually carried out are:

- **Functional analysis**
- **Specification analysis**
- **Human factor analysis**
- **Market analysis**
- **Economic analysis**

Functional Analysis

As we have noted earlier, every product, structure, or technological system is designed to meet human needs or wants. Functional analysis evaluates the degree to which the product meets its goal. It answers the basic question, “Will the artifact operate effectively under the conditions for which it was designed?”

These conditions may relate to the outside environment (weather, terrain, or water, for example), operating conditions (stress, heat, or gasses produced during use, for example), human use and abuse and normal wear (material fatigue or part distortion, for example).

Specification Analysis

Every product must meet certain specifications. These specifications may be given in terms of size, weight, speed, accuracy, strength, or a number of other factors. The specifications for all new products and structures must be analyzed.

Holding bicycle handlebar diameters to 1/1000” (.025mm) is foolish. That level of precision is not needed for the part to function. Tolerances (the amount a dimension can vary and still be acceptable) must be close for spark plugs threads, however. The goal is to produce an economical, efficient, and durable product that will operate properly and safely.

Human Factors Analysis

To meet human needs, we design artifacts and structures for the people who will use them, travel in them, or live and work in them. Designing products and structures around the people who use them is the focus of human factors analysis, more commonly known as ergonomics.

This science considers the size and movement of the human body, mental attitudes and abilities, and senses such as hearing, sight, taste, and touch. Ergonomics also considers the type of surroundings that are the most pleasing and help people to become more productive.

A good example of matching the environment to humans is an aircraft flight deck. All the controls are within easy reach. Dials and indicator lights are within the pilot's field of vision. Windows are located so that the pilots have a clear view of the sky ahead and above them.

A pilot runs through a systems check prior to take-off in a 747 jumbo jet.

Market Analysis

Most products of technology are sold to customers. These customers may be the general public, government agencies, or businesses. During design activities the market for a product must be studied. The designs must be analyzed in terms of that market.

Market analysis will include finding customer expectations for the product's appearance, function and cost. It will also include studying present and anticipated competition. Market analysis is often conducted by taking surveys of potential customers and analyzing competing products that are available on the market.

Economic Analysis

Most technological artifacts and structures are developed by private companies. They risk money to develop, produce, and market the items. In turn, they hope to make a profit for their risk taking. To increase their chances of success, individuals will often conduct a financial analysis for the new products.

The product is studied in terms of the costs of development, production, and marketing. These data are compared with expected sales income to determine the financial wisdom for producing the product. The higher the return on investment, the better the anticipated financial returns for the company.

Redesigning Products and Structures

The final goal of all products and structure development activities is to design an artifact that will help people control or modify the environment. This goal requires that the problem-solving/design process be continual. Needs are identified and defined. Solutions are designed and modeled. The designs are analyzed, and flaws are identified.

Redesign is then often required. Problems in the original design must be solved. New designs may be altered. New models will be built and evaluated until an acceptable product or structure emerges. This is not the end of the process. Products have a life expectancy.

New technologies and changes in people's needs and attitudes make some products obsolete. Old products will need redesigning, and new product definitions will appear. Product and structure design is a never ending process.

Summary

- Design solutions are evaluated using conceptual, physical, and mathematical models at various intervals of the design process
- Conceptual models capture the designer's ideas for specific structures and products
- Mathematical models show relationships in terms of formulas
- Physical models are three-dimensional representations of reality
- A mock-up is used to evaluate the aesthetic feature of a product
- A prototype is a working model of a system or a product
- Models allow designers to study and refine specific mechanisms and the total product
- Functional Analysis determines if a product or system does what it is designed to do
- Specification Analysis determines if a product or system meets the criteria and constraints established for it
- Human Factors Analysis determines if people can easily use a product or system
- Market Analysis determines if a product or system meets the needs and wants of customers
- Economic Analysis determines if a product or system can be produced and sold at a profit
- Shortcomings in the design are improved through redesign activities
- An acceptable design emerges after a rigorous analysis