# PLTW GTT DM Science Frameworks

**PLTW Course:** GTT Design and Modeling

**Science Strand being addressed:** The Nature of Science and Engineering

**Sub-strand being addressed:** The Practice of Engineering

## Overview:

**Science Standard and Benchmarks:** 6.1.2.2.1

**Science Standard 6.1.2.2:** Engineering design is the process of devising products, processes and systems that address a need, capitalize on an opportunity, or solve a specific problem.

**Benchmark 6.1.2.2.1:** Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system that solves a problem.

**Correlation to AAAS Atlas:**
MN 6.1.2.2 = AAAS 8B/M7

## Essential Understandings/Big Ideas:

The design process has evolved over centuries because the need to solve problems quickly forced people to refine the process. Each time a complex problem was solved, people studied the process along with the created solutions. Although the process goes by many names, the essential elements are the same. The benefits of using a design process are more evident today than ever. The speed with which we can research solutions with today's design tools has increased exponentially. Early people used trial and error as their only design process. This was an extremely slow. The process today allows for a faster solution and can be used to manufacture parts that are nearly identical. The use of these interchangeable parts allows for a more efficient assembly, as time is not needed to customize the fit of different parts.

Using a design process to solve problems helps us achieve an optimal solution. A design process should encourage the consideration of many possible solutions. Likewise, legal, environmental, and ethical issues will impact the chosen solutions. The process of design takes into consideration the elements of design: design is purposeful, it is based on certain requirements, it is systematic, it is iterative, it is creative, and there are many possible solutions. In addition, aesthetic and ergonomic considerations are an important part of any solution. Sometimes constraints are placed on the best solution to a problem. The process of optimization recognizes the concept of compromise among constraints.

### What should students know and be able to do [at a mastery level] related to these benchmarks?

- Describe the design process and how it is used to aid in problem solving.
- Use the design process to solve a technical problem.
- Recognize design criteria and constraints.
- Describe the purpose and importance of working in a team.
- Explain a design brief and apply the concept when using the design process.
- Describe the elements of design and apply this concept to the design process.
- Use a decision matrix to select the best solution to a design problem.

## Misconceptions:

### Student Misconceptions

- There is only one design.
- Criteria and constraints are not important.
- Evaluation and testing a product are not important.

## Teacher Resources:

This lesson focuses on the tools that engineers use to solve problems. Students will study the adopted GTT Design Process and will use it to guide their actions. It is important to know that this 9-step process is a stepping stone for middle school students in learning the 12-step design process used in the high school Pathway To Engineering PLTW® courses. For purposes of this lesson and the GTT course, the design process includes the following 9 steps:

- Define the problem
- Brainstorm
- Research
- Develop ideas
- Choose best idea
- Model or prototype
- Test and evaluate
- Improve design
- Communicate results

In this lesson students will be introduced to the idea that there are many design processes and no single design process is better or more useful than another. They will learn that the selected design process will be built upon in the high school Pathway to Engineering™ courses. Students will encounter each step in more detail as they gain knowledge and experience throughout the course.

Teachers can choose to provide the furniture design or hobby organizer design or allow their students to choose which design project they would prefer. Students will use the design process to design a table or chair or an organizer for their favorite hobby. In this introductory unit, we will complete steps 1-5 of the design process. We will continue with the other steps later in the course. Students should keep completed work in their portfolio until they progress further into the Design and Modeling unit.

You will have to introduce students to a design brief either through the **Design Brief GTT.ppt** or by reviewing the sections and the purpose of each section. Students will create their own design brief to be dictated by the desired goal of their piece of furniture. Student groups may need teacher assistance through this process since each group has a different idea of the purpose or function of their piece of furniture.

It is necessary to discuss with students the importance of teamwork. Emphasize how to be a good partner, how to encourage your partner, how to include your partner, how to be a good listener, etc. Brainstorm this discussion to demonstrate the brainstorming concept and to identify the characteristics necessary for teams to be successful.

## Teacher Notes

- Use the simplified 9-step design process for the GTT course only. DO NOT use this design process with high school courses. The intent of this is to not overwhelm our younger GTT students. If, however, you are teaching the design process to a student population that you think is capable of learning the 12 step design process, feel free to use the presentation available in the Introduction to Engineering Design (IED) curriculum.
- Students should be reminded that there is no one single design process that serves as a standard for all designers. However, this is the specific process that will be used in the GTT course. The remainder of the PLTW courses will use the 12 step design process.
- Teachers can choose to provide the furniture design or hobby organizer design or allow their students to choose which design project they would prefer. Students will use the design process to design a table or chair or an organizer for their favorite hobby.
- In this introductory unit, we will complete steps 1-5 of the design process. We will continue with the other steps later in the course.
- Students should keep completed work in their portfolio until they progress further into the Design and Modeling unit.

## What is it that students struggle with the most and how can the teacher most effectively help students learn the concepts?

- Knowledge that designers have many options. Picking and choosing methods for each project works well.

## Additional Instructional Resources

- Design Brief GTT PowerPoint; Google Docs GTT Resources / Design and Modeling
- Design Process PowerPoint; Google Docs GTT Resources / Design and Modeling
- Design Elements PowerPoint; Google Docs GTT Resources / Design and Modeling

http://pbskids.org/designsquad/

http://www.yikebike.com/design/video-gallery/yikebike-discovery-channel

## New Vocabulary

| | |
|---|---|
| **Aesthetics** | Pleasing in appearance. |
| **Annotate** | A sketch on which notes are made to provide further information. |
| **Brainstorming** | A method of shared problem-solving that all members of a group spontaneously, and in an unrestrained discussion, generate ideas. |
| **Constraints** | A limit to the design process. Constraints may be such things as appearance, funding, space, materials, and human capabilities. |
| **Consumer** | A person or household that purchases goods or services. |
| **Criteria** | Desired specifications (elements or features) of a product or system. |
| **Decision Matrix** | A tool for systematically ranking alternatives according to a set of criteria. |
| **Design** | An iterative decision-making process that produces plans by which resources are converted into products or systems that meet human needs and wants or solve problems. |
| **Design Brief** | A written plan that identifies a problem to be solved, its criteria, and its constraints. The design brief is used to encourage thinking of all aspects of a problem before attempting a solution. |
| **Design Elements** | The factors (e.g., line, color, light, shadow, space, texture) that define a product and take into account the aesthetics and function of the product. |

| | |
|---|---|
| **Design Process** | A systematic problem-solving strategy, with criteria and constraints, used to develop many possible solutions to a problem or to satisfy human needs and wants and winnow (narrow) down the possible solutions to one final choice. |
| **Designer** | A person who designs any of a variety of things. |
| **Dimension** | A measure in one direction. |
| **Engineer** | A person who is trained in and uses technological and scientific knowledge to solve practical problems. |
| **Ergonomics** | The study of workplace equipment design or how to arrange and design devices, machines, or workspace so that people and things interact safely and most efficiently. |
| **Evaluate** | To form an idea of the amount or value of; assess. |
| **Experimentation** | The act of trying out a new procedure, idea, or activity. |
| **Exponentially** | Extremely rapid increase. |
| **Investigate** | To observe or study by close examination and systematic inquiry. |
| **Model** | A visual, mathematical, or three-dimensional representation in detail of an object or design, often smaller than the original. A model is often used to test ideas, make changes to a design, and to learn more about what would happen to a similar, real object. |
| **Modify** | Change to ensure accuracy. |
| **Optimize** | An act, process, or methodology used to make a design or system as effective or functional as possible within the given criteria and constraints. |
| **Problem Solving** | The process of understanding a problem, devising a plan, carrying out the plan, and evaluating the plan in order to solve a problem or meet a need or want. |
| **Process** | Human activities used to create, invent, design, transform, produce, control, maintain, and use products or systems; a sequence of actions that combines resources to produce an output. |
| **Prototype** | A full-scale working model used to test a design concept by making actual observations and necessary adjustments. |
| **Requirements** | The parameters placed on the development of a product or system. The requirements include the safety needs, the physical laws that will limit the development of an idea, the available resources, the cultural norms, and the use of criteria and constraints. |
| **Research** | Systematic, scientific, documented study. |
| **Specification** | A detailed description of the design and materials used to make something. |
| **Testing** | A method for collecting data. |
| **Texture** | The feel, appearance, or consistency of a surface, substance, or fabric. |
| **Trade-off** | An exchange of one thing in return for another; especially relinquishment of one benefit or advantage for another regarded as more desirable. |
| **Visualization** | Formation of mental **visual** images. |

# Vignette:

The class is preparing for the start of a new design unit involving furniture in a home. The teacher shows the class some examples and points out the good and bad of each.

Teacher: The design process is a purposeful method of planning practical solutions to problems. The design process is never final; there are always multiple solutions to a problem. The design process is influenced by requirements called criteria and constraints.

Student: What is Design?

Teacher: Design is a creative planning process that leads to useful products and systems.

Student: Are all designs perfect?

Teacher: There is no perfect design. Requirements of a design are made up of criteria and constraints.

Student: What are criteria?

Teacher: Criteria are desired specifications (elements or features) of a product or system.

Student: What is a constraint?

Teacher: It is a limit to the design process. Constraints may be such things as appearance, funding, space, materials, and human capabilities.

Student: How do we begin this?

Teacher: By defining the problem. It is like conducting detective work. You must examine the evidence and form some conclusions.

Student: What are some examples?

Teacher: Design a vehicle that can communicate with other vehicles to prevent accidents. Design an athletic shoe that decreases the amount of sprained ankles when worn on hardwood gym floors.

Teacher: The next step is to brainstorm.

Student: What's that?

Teacher: Brainstorming involves bringing a group of people together to generate many different ideas.

Student: You mean thinking about the athletic shoe bottom being made of rubber so it grips the floor?

Teacher: You have the right idea now!

Teacher: Research is next. This may require going to the library, using computer databases, writing letters, performing experiments, and asking questions.

Student: I can do this by using books and magazines, looking at videos or searching the Internet.

Teacher: Yes, then you develop multiple ideas that will solve the problem and meet the requirements.

Student: By using criteria and constraints!

Teacher: That's right. Then you decide on an idea that best meets the criteria, fits within the constraints, and has the least amount of negative characteristics.

Student: How can I do that?

Teacher: You can list the strengths and weaknesses of each.

Student: Like making improvements to the design idea for better performance or increased safety?

Teacher: Correct!

Teacher: Then you build a model or a prototype.

Student: I know what a model is. But what's a prototype?

Teacher: It is a working model; it looks and functions just like the finished product.

Student: I get it. A prototype of my desk would look the same as the real thing!

Teacher: Then we test and evaluate. Models of design solutions must be tested and important questions must be answered during the evaluation.

Student: So it's comfortable, looks good and works like it should.

Teacher: Correct. Sometimes you need to improve on the design after studying, testing data and evaluating design solutions

Student: Is the process finished now?

Teacher: Almost. You need to share your design ideas with others to prove the design is worthy of manufacturing.

Student: By making a poster?

Teacher: Yes. You could also use drawings, charts, presentation and reports.

# Assessment:

## Assessment Methods

1. What is the design process and how is it used?
2. Why is brainstorming important when modifying or improving a product?
3. Why do people work in teams when solving design problems?
4. What is meant by constraints and criteria?
5. Which step in the design process uses a design brief? Why?
6. Which step in the design process uses a decision matrix? Why?
7. Why are design elements considered when engineers and designers invent or innovate a product?

# Differentiation:

## Gifted and Talented

* Students can add three steps and use the 12-step process from the IED/DDP curriculum.

## Special Education

- Students on an IEP and those who struggle could have extra handouts and related materials (computer simulations, videos and Internet links) made available to them.

## English Language Learners

- Much of the vocabulary used in this area can be difficult for the ELL student. Using pictures that are shown in build sheets could help. Completed examples of the design process would be of assistance to the ELL students.
- This information would have to be reinforced through the help of the ELL teacher.

# Parents and Administration:

## Administrative/Peer Classroom Observation

| Students Are: | Teachers Are: |
|---|---|
| Using the design process | Questioning students |
| Documenting problems | Monitoring progress |
| Adjusting and making changes | Reinforcing success |
| Testing and Evaluating | Redirecting problems |

## Professional Learning Communities:

**Reflection – Critical Questions regarding the teaching and learning of these benchmarks:**

- In what areas did students perform best and what weaknesses are evident?
- How can this content be connected to other benchmarks in learning?
- Do students see the connection between steps in the design process?
- Are students interpreting information correctly?
- What areas did students perform best and what weaknesses?

**Materials – suggested articles and books for book study with PLC** ~ The Design Process

## Parent Resources:

- Allowing their children to practice problem-solving skills at home.
- Encourage children to be willing to experiment with concepts that involve the design process.
- http://www.edheads.org/

## References:


- Project Lead the Way; Gateway To Technology, Design and Modeling; course curriculum.
- Minnesota Academic Standards - Science K - 12 2009 version.
- AAAS Benchmarks
- http://www.project2061.org/publications/bsl/online/index.php?home=true