Understand the Reverse Engineering Process

Unit. Technology
Problem Area. Engineering Design
Lesson. Understand the Reverse Engineering Process

Student Learning Objectives. Instruction in this lesson should result in students achieving the following objectives:

1. Describe reverse engineering.
2. Identify the steps in the reverse engineering process.
3. List the reasons for reverse-engineering a product.

List of Resources. The following resources may be useful in teaching this lesson:

List of Equipment, Tools, Supplies, and Facilities

- Overhead or PowerPoint projector
- Visual(s) from accompanying master(s)
- Copies of sample test, lab sheet(s), and/or other items designed for duplication
- Materials listed on duplicated items
- Computers with printers and Internet access
- Classroom resource and reference materials

Terms. The following terms are presented in this lesson (shown in bold italics):

- design
- durability
- forward engineering
- functionality
- product definition statement (PDS)
- reverse engineering
- subsystems

Interest Approach. Use an interest approach that will prepare the students for the lesson. Teachers often develop approaches for their unique class and student situation. A possible approach is included here.

Reverse engineering is the systematic process of obtaining critical design and engineering information from an existing product. Present students with an easily recognized technology system that might have been subjected to the reverse engineering process (e.g., a power hand drill). Ask the students to identify the engineering resources (core technologies) that are present in the technology system. Ask them to speculate on why an individual or organization might want to reverse-engineer a product.

SUMMARY OF CONTENT AND TEACHING STRATEGIES

Objective 1: Describe reverse engineering.

Anticipated Problem: What is reverse engineering?

1. There are two types of engineering: forward and reverse.
   A. Forward engineering
1. **Forward engineering** is the traditional process of moving from high-level abstractions and logical designs to the physical implementation of a system.

2. In some cases, there may be a physical part without any technical details, such as drawings and bills-of-material.

3. In other cases, there may be a physical part without engineering data, such as thermal and electrical properties.

B. Reverse engineering

1. **Reverse engineering** is the process of taking something (e.g., a device, an electrical component, a software program) apart and analyzing its workings in detail, usually with the intention of constructing a new device or program that does the same thing without actually copying anything from the original.

2. The objective of the reverse engineering process is to capitalize on successes and learn from the shortcomings of existing designs.

3. Reverse engineering is very common in such diverse fields as software engineering, civil engineering, the automotive industry, electronics, and the chemical industry.
   a. When a new product comes out on the market, competing manufacturers may buy one in order to disassemble it and learn how it was built and how it operates.
   b. For example, a chemical company may use reverse engineering to defeat a patent on a competitor’s manufacturing process.
   c. In civil engineering, building and bridge designs are often copied from past successes to decrease the likelihood of catastrophic failure.
   d. In software engineering, a good source code is often a variation of an already existing source code.

4. Typically, reverse engineering is only cost-effective if the item to be reverse-engineered reflects a high investment or will be reproduced in large quantities.

5. Reverse engineering begins with the product and works backward through the design process to arrive at a **product definition statement (PDS)**. In doing so, it uncovers a lot of information about the design ideas that were used to produce a particular product.

Many techniques can be used to help students master this objective. As an example, use LS–A to give students a historical example of the reverse engineering process.

**Objective 2:** Identify the steps in the reverse engineering process.

**Anticipated Problem:** What are the steps in the reverse engineering process?

II. There are six steps in the reverse engineering process.

A. Prediction
   1. What is the purpose of this product?
2. How does it work?
3. What market was it designed to appeal to?
4. List some of the design objectives for the product.
5. List some of the constraints that may have influenced the design.

B. Observation
1. How do you think it works?
2. How does it meet design objectives (overall)?
3. Why is it designed the way it is?

C. Disassemble
1. How does it work?
2. How is it made?
3. How many parts?
4. How many moving parts?
5. Any surprises?

D. Analyze
1. Carefully examine and analyze subsystems (i.e., structural, mechanical, and electrical).
2. Develop annotated sketches that include measurements and notes on components, system design, safety, and controls.

E. Test
1. Carefully reassemble the product.
2. Operate the device and record observations about its performance in terms of functionality (operational and ergonomic) and projected durability (i.e., its power to resist stress or force).

F. Documentation
1. Inferred design goals
2. Inferred constraints
3. Design (functionality, form (geometry), and materials)
4. Schematic diagrams
5. Lists (materials, components, critical components, flaws, successes, etc.)
6. Identify any refinements that might enhance the product’s usefulness.
7. Upgrades and changes

Many techniques can be used to help students master this objective. As an example, use VM–A to illustrate the steps in the reverse engineering process.
Objective 3: List the reasons for reverse-engineering a product.

Anticipated Problem: Why would an individual or organization want to reverse-engineer a product?

III. There are several reasons for reverse-engineering a product.

A. The original manufacturer of a product no longer produces the product.
B. There is insufficient documentation of the original design.
C. The original manufacturer no longer exists, but a customer needs the product.
D. The original design documentation cannot be retrieved or never existed.
E. Some bad features of a product need to be removed (e.g., excessive wear might indicate where a product needs to be improved).
F. To strengthen the good features of a product based on long-term use of the product
G. To analyze the good and bad qualities of a competitor’s product
H. To explore new ways of improving product performance
I. To gain competitive benchmarking methods in order to understand a competitor’s product and develop a better product
J. The original supplier cannot or will not provide additional parts.
K. The original equipment manufacturers cannot or will not supply replacement parts, or charge inflated prices for sole-source parts.
L. To update obsolete materials or outdated manufacturing processes with more current, less-expensive technologies

Many techniques can be used to help students master this objective. As an example, use LS–A to give students a historical example of reverse-engineering a product.

- Review/Summary. Use the student learning objectives to summarize the lesson. Have students explain the content associated with each objective. Student responses can be used in determining which objectives need to be reviewed or taught from a different angle. Questions at the ends of chapters in the textbook may also be used in the review/summary.

- Application. Use the included visual master and lab sheet to apply the information presented in the lesson.

- Evaluation. Evaluation should focus on student achievement of the objectives for the lesson. Various techniques can be used, such as student performance on the application activities. A sample written test is provided.
**Answers to Sample Test:**

**Part One: True or False**

1. True
2. False
3. True
4. False
5. True

**Part Two: Completion**

1. Durability
2. subsystems
3. product definition statement
4. functionality
5. design

**Part Three: Short Answer**

1. prediction; observation; disassemble; analyze; test; documentation
2. Students could give any three of the reasons listed in Objective 3.
Part One: True or False

Instructions: Write T for True or F for False next to each statement.

1. The systematic process of obtaining critical design and engineering information from an existing product is called reverse engineering. T

2. Software reverse engineering involves copying an existing source code exactly. F

3. Forward engineering is the traditional process of moving from high-level abstractions and logical designs to the physical implementation of a system. T

4. Reverse engineering is uncommon in such diverse fields as software engineering, civil engineering, the automotive industry, electronics, and the chemical industry. F

5. Reverse engineering is cost-effective only if the product to be reverse-engineered reflects a high investment or will be reproduced in large quantities. F

Part Two: Completion

Instructions: Provide the word or words to complete the following statements.

1. _________________________ is the power to resist stress or force.

2. The structural, mechanical, and electrical components of a system are called _________________________.

3. Reverse engineering begins with the product and works backward through the design process to arrive at a ______________________________.

4. Operational and ergonomic aspects determine a product’s _________________________.

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5. Functionality, form, and materials make up the ______________________ of a product.

**Part Three: Short Answer**

*Instructions: Complete the following.*

1. List the six steps in the reverse engineering process.

2. Give three reasons for reverse-engineering a product.
STEPS IN THE REVERSE ENGINEERING PROCESS

♦ Prediction
♦ Observation
♦ Disassemble
♦ Analyze
♦ Test
♦ Documentation
Reverse-Engineering a B-29 Bomber

Purpose
The purpose of this activity is to enhance students’ understanding of the reverse engineering process.

Objective
Demonstrate comprehension of the article by answering questions related to the article.

Materials
♦ computers with Internet access
♦ copies of lab sheet
♦ writing utensils

Procedure
1. Have students read the article, “How Soviets Copied America’s Best Bomber During WWII” (see http://archives.cnn.com/2001/US/01/25 smithsonian.cold.war/).
2. Have students answer the questions about the article.
Reverse-Engineering a B-29 Bomber

Instructions

Read the article, “How Soviets Copied America’s Best Bomber During WWII,” and then answer the following questions.

1. When the American B-29s made emergency landings in Vladivostok in 1944, why did the U.S. pilots assume the planes would be in safe hands?
2. How long did it take Soviet engineers to reproduce the B-29?
3. The Soviets reproduced the B-29 almost exactly, including its flaws. What was one design flaw that was copied?
4. What was the name of the B-29 that dropped the first atomic bomb on Japan in 1945?
5. What happened to the three confiscated bombers?
Reverse-Engineering a B-29 Bomber

1. The United States and Russia were allies during WWII.
2. two years
3. The B-29 engine had a tendency to catch fire.
4. Enola Gay
5. One was used as a model, one was used for test flights, and one was disassembled.