Session 10

Bicycle Breakdown: Systems, Components and Parts

Making, Modeling, and Materializing

In This Session:

A) Systems and Synergy (50 minutes)
- Student Handout
- Student Reading

B) Sum of the Parts (100 Minutes)
- Student Handout

Bicycle Breakdown: Systems, Components, and Parts uses the mechanisms of a bicycle to help you think about the systems in a product that must be designed. It offers a strategy for tackling a complex solution that you might have in mind. It provides practice with breaking big ideas into manageable, designable parts by identifying systems and/or components that need design and engineering.

In the first activity, *10A: Systems and Synergy*, learn the difference between systems, components, and parts as you identify them on a bicycle. The second activity, *10B: Sum of the Parts*, involves a field trip to a bike store or a demonstration on a bicycle's systems, components, and parts.

Systems and Synergy

Handout: Session 10, Activity A

Sample Title
The bicycle can be organized into four major systems (see table below). Sometimes a bigger system is made up of smaller systems, or subsystems. Systems can also share the same components. For example, every system listed below makes use of the wheels.

A bicycle has four major systems:

Major System	Purpose	Example Components
1. Drive System	Power you along efficiently under your own steam	Pedals, chain, gears, wheels, transmission subsystem
a. Transmission Subsystem	Shift gears and allow you to adjust for changes in terrain	Gear shifter, cables, derailleur, derailleur gears, hub gears
2. Braking System	Make the bicycle stop reliably at a moment's notice	Wheels, caliper brake subsystem, or coaster brake subsystem
a. Caliper Brake Subsystem	Apply pressure to rim of tire	Brake lever, cables, caliper arms, brake pads
3. Steering System	Turn the bicycle	Handlebars, stem, wheels, frame system
4. Structural System	Support and connect you and the other systems together during operation	Frame, handlebars, wheels, suspension subsystem
a. Suspension Subsystem	Allow wheels to move up and down to absorb bumps in a road	Shock absorber with spring and damper parts

Using the diagram below, highlight the different systems. Each system should be one color—include a color key.

What's a System?

Reading: Session 10, Activity A

System: A group of related subsystems or components that form a whole functioning device.

Synergy: The combined power of a group of things when they are working together which is greater than the total power achieved by each working separately.

Important problems often have very simple solutions. But what is simple? A solution may be very elegant and seem obvious until you start to examine how to make it. Designed things can be deceiving. At first glance, they are so functional and seem so simple to use. But being simple to use does not necessarily mean it is easy to engineer. A very important skill is the ability to analyze, to break down your design solution into the smaller systems and components that work together to make a functioning product. It will help you to think about systems within your product as you design and create a prototype.

Systems are very important to engineering and design. They make the design process much easier. Imagine if you had to design a Boeing 777 airplane, a huge and complex task. However, the task becomes more manageable if you were on a team to design the wing system, another team of engineers designs the landing gear system, another team designs the fuselage system, etc.

Are Bicycles Simple?
Bicycles are everywhere; they are so familiar you almost take them for granted, right? Most of us have ridden bicycles or tricycles. It's pretty easy to think about different things you expect a bicycle to do. Take a minute to analyze how you use a bicycle: You sit on it comfortably, make it go, you make it stop, you make it go fast on flat places, and you make it go up steep hills. In many ways bikes seem so simple. Yet each of these things that you expect a bicycle to do requires a different system. Each system has essential components, and each component may be made of several parts.

What Makes a System?
A mechanical system is made up of components and parts that connect to perform a function. Think about using the brakes on a bike. There are several components (each with parts) that make up the brake system. On most bikes today, you stop by grasping brake levers that have parts to attach the levers to the frame and other parts that connect them to cables that move as you pull. As cables are pulled, brake arms squeeze together on brake shoes that grip on the wheel and slow it down.

Sum of the Parts

Handout: Session 10, Activity B

Chances are you have had some experience with bicycle mechanisms. Perhaps you've had to fix or adjust something on a bicycle or have watched while someone else did quick maintenance during a ride. Have you ever really looked at a bike and studied how it works? A bicycle has a set of mechanical systems that are familiar and easy to observe.

Directions
Study four systems on your bicycle. You'll also be able to observe and operate the components and parts of each system that are removed from a bike. This will give you another way to observe how things connect and work together.

Systems Study

1. Drive system: Support the bike with the rear wheel off the ground (turn the bike on its side, use a stand, or have a partner hold the bike up.) Slowly power the bike using the pedals and study how the energy you add transfers through the drive system to the wheels. Switch partners.

2. Braking system: Study how the brakes work as you press and release the brake lever. Trace the operation of the brakes through components and their parts. Notice the connections.

3. Steering system: Study how you steer a bike. Trace the steering through the handlebar to the wheels. Notice the connections.

4. Structural system: Study the frame and how all the systems connect to it.

Components and Parts Study
Observe and take notes about how parts connect and work together in each of the systems. Which systems seem simple and require few parts? Which systems seem complex and require more parts and complicated connections? Which systems seem easy to break down? Which systems seem easy to repair? Your notes may consist of words or sketches.

Drive system:

Braking system:

Steering system:

Structural system:

Specialty bikes: Identify and study the four systems in each of the specialty bikes. Compare them to the systems in the more traditional bicycle. What did you observe?

Optional: Using an Erector* set for parts, make your own model vehicle. Try to incorporate the four systems you studied: structural, drive, steering, and braking.