Bicycle Designs

Imagine sitting on a board that has two wheels bolted underneath to make it go. The board is thin and you sit on it much as you would a horse. If you push with your feet, you can make it go forward or backward. If you build enough speed you can lift your feet and coast awhile. Heading downhill provides a lot of speed and is very exciting.

Does this sound like something you have tried? You may think it sounds like riding a bicycle. In many ways you are right. What you have just imagined is called a Draisine. It was built long before bicycles were invented. Look at the picture of the Draisine in Figure 1 and notice the ways that it is the same as a bicycle and the ways that it is different. What is missing?

The Draisine was invented by Karl Von Drais in the early 1800s. In fact, to some Mr. Drais is known as the "Father of the Bicycle." Drais' purpose in making his two wheeled invention was to find a way to travel the miles of forest trails that belonged to his boss. The Draisine allowed him to cover the trails that he watched over more quickly (Pursell, 1980).

As you can see in Figure 1, the front wheels of the Draisine do not turn for steering and there are no brakes. A bicycle that cannot be steered and that is difficult to stop is very risky. For this reason, many of Drais' neighbors wanted him to keep his machine in the forest and out of town. He had a lot of work to do to make his Draisine more safe and useful. In fact, he really never improved it and as a result, people lost interest in his invention (Pursell, 1980).

Although Drais never created a bicycle like the one we have today, the ideas that he had were used by

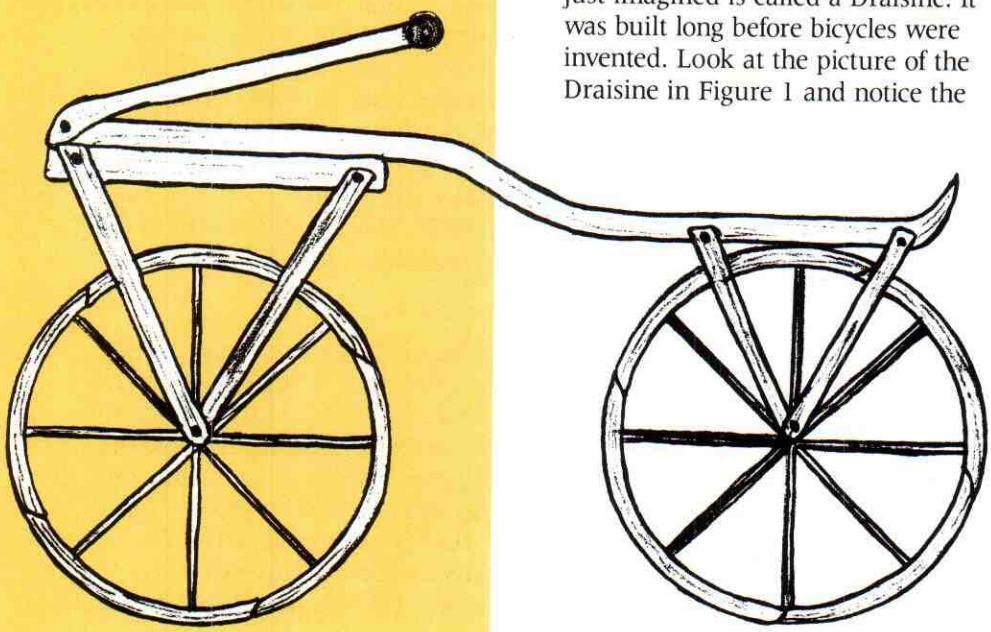


FIGURE 1. This is a picture of the Draisine, invented by Karl Von Drais. It is one of the very first bicycles. Notice that it cannot be steered and has no brakes. ***Courtesy T. Danae Thompson.***

many inventors as they added their own ideas. Some of the ideas worked and some proved to be worse than the original. For each invention of the bicycle, a lot of ideas had to be put together so it would work. These ideas are the beginning of something called **design**.

Let's find out more about this word design. The word design can be used in a lot of different ways, but you must keep in mind that it is always a process. Every designer goes through the same basic steps while creating a design. These steps are:

1. Thinking of an idea.
2. Planning a drawing.
3. Making a design.

Most people who want to invent something need to complete all of these steps in designing before they have a worthwhile product.

STOP! What are the steps in creating a design?

Thinking of an Idea

The first part of designing, where someone thinks of an idea in their mind, happens all of the time. Every time a person has a problem, they begin to think of ways to solve it in their minds. Drais probably began to think of his design each day as he walked on and on down those long forest trails. As his feet began to hurt, he probably dreamed about how nice it would be to sit down. As time wore on, he must have imagined ways to rest his feet but to continue down the trails. Someone may have passed him in a horse drawn carriage, making him think how nice it would be to have a seat with wheels. Can you see how he may have begun his design?

What made people want to improve his design? Well it is possible that sitting on a Draisine that is heading downhill toward a lake would start the ideas coming, especially if you had your best friend sitting behind you. That person probably would have a few ideas of their own.

STOP! What makes people begin thinking of ideas?

Planning a Drawing

Many drawings have been found by people who worked out their ideas on paper. For example Michelangelo, the famous artist, made many drawings of all the ideas that he had in his mind. The inventors of the bicycle did the same thing. This putting ideas on paper is the next step in designing. Today, manufacturers (the people who make bicycles and other things), need to work things out on paper as well. They usually use a computer which has programs that help them in their work. On their computers, there are programs that help solve mathematical and scientific equations. The use of the computer increases the designer's ability to come up with more exact plans. For example, if you give the computer the circumference, or the measurement around the outside of the wheel, the computer will figure out exactly how far apart the spokes need to be from each other. Or you might tell the computer how long and tall you want your bicycle to be. With this information, it would give you the measurements for the tubes on the bike. This work that the computer helps create on paper (or computer screen) is called the **working plan**. It will be the road map for building the final product.

Michelangelo, was much like Draisine, in that he did not actually build many of his ideas. This part of the design process can be the most challenging. Here is where you take all of your ideas and see if they actually work. Many times you will follow your working drawings only to find that they don't work. This means that you will need to "go back to the drawing board". You will need to get out the old computer and try some new ideas. Don't get discouraged. This just means you are like most inventors. They all invented a lot of mistakes before they invented the design that made them famous.

STOP! What is a design on paper or computer screen called?

Now let's look at the modern mountain bikes that are so popular today. We have a picture of a child's mountain bike in Figure 2 and an adult cross-country mountain bike in Figure 3. These two bicycles can tell us a lot about why modern bicycle designers come up with their final designs (Trek USA, 1995).

First, we need to point out the main differences in the **purpose** for each bike. The child's mountain bike is mostly for play, while the adult bike is for more serious cross-country racing. Next, let's consider how this difference will effect the design. In order to do this, we must remember that the bike is not just one design but a group of designed parts that work together. We won't look at every part, but we will focus on the frame, the wheels, and some of the smaller parts.

STOP! Why are the designs of the two mountain bikes different?

Frame

The bicycle frame can be described as a set of three triangles that share one side. The first triangle is between the handle bars and the seat and the other two triangles reach behind on either side of the rear wheels. This can best be seen in Figure 4. The reason for the three triangles is strength. The side that they share in

FIGURE 2. Here is a child's mountain bike. Notice all of the neat attachments. It has a headlight that is powered by the front wheel, a bookrack, front and rear fenders (to protect the rider from mud) and hand brakes. *Courtesy Trek® Bicycle Corporation.*

the middle adds extra support. You'll notice that this support happens to be right underneath the seat. This is where the most weight, from the rider, will be located.

Take a look at the child's mountain bike in figure 2. On this particular bicycle the other sides of the triangles are somewhat long and narrow. This forms a bicycle that is more stretched out, creating an aerodynamic design. The word **aerodynamic** describes something that is rounded or thin, so it moves easily through air. You will see that the tubes which make up each triangle are very thin.

FIGURE 3. This is an adult cross-training mountain bike. It has a shock absorber built into the frame. This bike frame is flexible. It can bend in the area under the seat. *Courtesy Trek® Bicycle Corporation.*

Another important aspect of the child's mountain bike frame is that it is simple. It is only made up of the tubes and there are no moving parts. This may make the design a little less exciting, but it also cuts down on the cost to make the bicycle.

STOP! What does aerodynamic mean?

Cost

Cost plays a large part in design. As the inventor, you may think that an expensive bicycle will make you a lot of money. Unfortunately, this isn't true. The more you spend on making a bicycle the less money you will have to keep after it is sold. Let's say that you design a bike and it costs you one hundred dollars to make then you sell it for one hundred dollars. You won't make any money on your design. If you can make a bicycle, that is just as good for eighty dollars and you sell it for one hundred dollars then you will have twenty dollars left over to keep. This twenty dollars is your **profit.** Profit is the extra money you made. Now you can understand why cost plays a big part in design. Cost will also affect the choice of materials that are used as well. Most frames are made of steel, aluminum, other metals and composites or a combination of these materials. Composite frames can be made of carbon fibers mixed with epoxy plastic. Steel is the least expensive, aluminum is next and carbon composite is quite expensive. A bicycle that is mostly made of steel will be the least expensive to make.

STOP! How does cost affect the materials you choose?

Wheels

Let's look at the wheels on the child's mountain bike in Figure 2. You will notice that the tires are wide and made of a thick material. The

FIGURE 4. Here we have a craft person painting the frame of the bike. The painter will hand spray the tight spots, and then a machine will spray the whole thing. This picture allows you to see the three triangles of the frame. *Courtesy Trek® Bicycle Corporation.*

tires also have a lot of spokes. All of these parts of the wheels' design were chosen with a plan. The wheels are wide to allow better balance. The thicker materials for the tires are to protect them from being punctured easily. And, the amount of spokes on the wheels give them strength to keep their shape. Any person who wants to go speeding over bumpy mountain trails will choose the design that has an aerodynamic frame but has wheels that can withstand the bumps and sharp rocks on a mountain trail.

STOP! What is the purpose for having wide wheels?

There are other parts of the design that help the bicycle be the most effective. These parts include the brakes, gears, handle bars, seats, bike racks, water bottles, and head lights. On a child's mountain bike, lots of "extras" make the bicycle more exciting and allow the rider freedom to do different types of activities. Each one of these items will need to be designed to attach to the bicycle. They will also need to be aerodynamic and light weight.

Now let's look at the adult cross-training mountain bike. If you look at Figure 3 you will see that this bicycle has fewer "extras" on it and that it is much more complicated around the frame area. While you will notice that the frame still has the three triangles, they are not made of simple tubes, and they do not share one side. The front triangle on the frame is thick and solid looking, with the rear triangles sticking through the middle of it. This particular design allows the frame to be more **compact**, with all of the parts closer together. With everything close together the bicycle will be stronger and able to handle even more bumps than the child's mountain bike. You will notice that the back triangle parts are made with a thicker, rectangular shape which adds strength. This design also allows the back triangle to move separately from the front, helping the bike to actually bend a little when it goes over bumps. If it didn't bend at all, the bumps would eventually weaken and loosen the parts and the bicycle would fall apart. Now you may be asking yourself, "Why isn't the child's bike made to be more flexible? I don't want my bike to fall apart either." Keep in mind that word **cost.** It plays a big part in design. The adult cross-training mountain bike is much more expensive than the child's bike.

STOP! Why is it better to have a compact bike?

How are the wheels different? The tires are wide like the child's bike, but they have much deeper grooves. This allows the bicycle to "grip" the ground better to avoid slipping. Also, notice the spokes. There are a lot of spokes, but if you'll count them there are not quite as many as on the child's. Can you guess why the

designer would choose to put fewer spokes on this more expensive bike? If you thought that more parts mean more weight, you are right. Even though lots of spokes make the wheel stronger, the moveable frame will help take some of the shock so fewer spokes are needed.

STOP! Why is it better to have fewer spokes on a bike?

Weight plays an important part in the design of a bicycle. If a bicycle is heavy, it makes it harder to carry around, and it takes more energy to peddle. This is why you will notice that the racing bike does not have any "extras". So, no matter how well these things are designed, they will add extra weight. For this reason, there are no head lights, book racks, or fenders. Even the peddles and seat are thin and lightweight compared to the child's bike.

The purpose of the child's mountain bike and adult cross-country bike are a little different so the design is a little different. Now let's take a look at a set of wheels for a toddler. (See Figure 5.) The purpose for this tricycle will be very different so the design will have lots of changes.

The change in design that is easiest to see is in the wheels. There are three instead of two. This allows for much easier balancing. Now you are probably thinking this will make the tricycle heavier. You are right. Some tricycles are very heavy. If you wanted to use the same frame and wheel design but have a lighter toy, what could you change? You're right, the materials.

The toddlers's tricycle does not need to be aerodynamic, so a bulky material like polypropolene can be used. It will be lighter than steel, but heavier than aluminum or carbon composite materials and it will also be less expensive. It will also be easier to make. (Jacobs, 1994)

FIGURE 5. This toddler has his own set of wheels. This tricycle is made of polypropylene. The parts are made in a mold. *Courtesy Fisher-Price.*

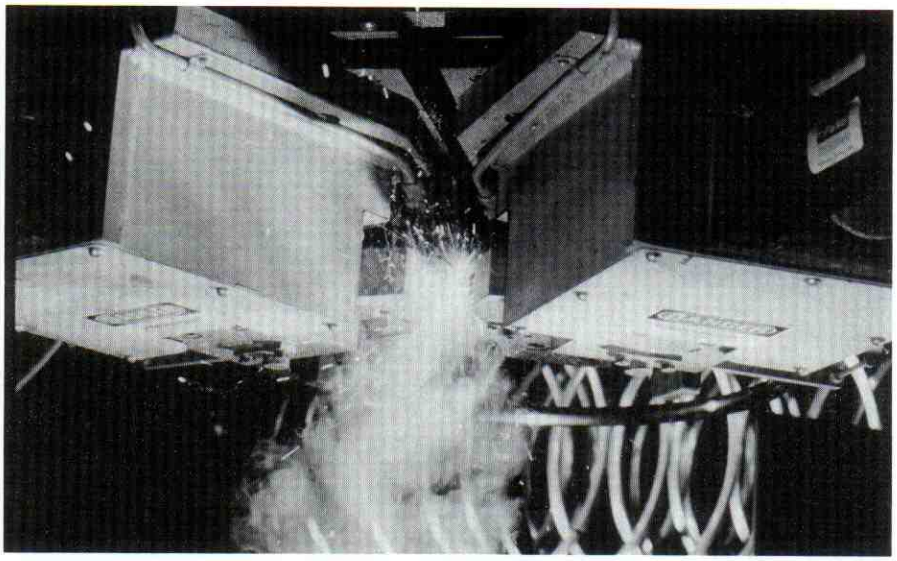
STOP! How will changing materials change the bike?

Making a Design

Another important thing to think of in designing a bicycle is how difficult or easy it will be to build or **assemble.** The mountain bikes have frames that need to be welded together by skilled welders. The wheel rims can be welded by automatic machines, as shown in Figure 6, that do not require as much skill as manual welding. Other methods of joining include using nuts and bolts and glue. Plus, these materials will need to be painted to protect from rust and to add color. The polypropylene tricycle is much easier to make. The color is simply added to plastic pellets which are melted and then pressed into a mold for the frame. The wheels, handle bars, and handles are all made the same way. The frame is one solid piece, so is each wheel. There are fewer parts to put together on the toddler's tricycle.

STOP! What does assemble mean?

Which of these assembly processes do you think is more expensive? If you said welding, you are right. The tubes that make up the frame on the mountain bikes must be joined exactly in line with each other. This work must be done by a skilled



welder. People who are highly trained must be paid more money. Working the molding machine for the tricycle does not require as much training. The workers for this job are not as expensive to hire. Also, after the frame of the mountain bike is assembled, it must be shipped to the store, where the gears, brakes, seat, pedals and everything else will be added. In Figure 7, we see these parts being attached to the frame. All of the other parts will be added and adjusted by this person. This involves

FIGURE 6. The wheel rims are being welded by an automatic welding machine. *Courtesy Trek® Bicycle Corporation.*

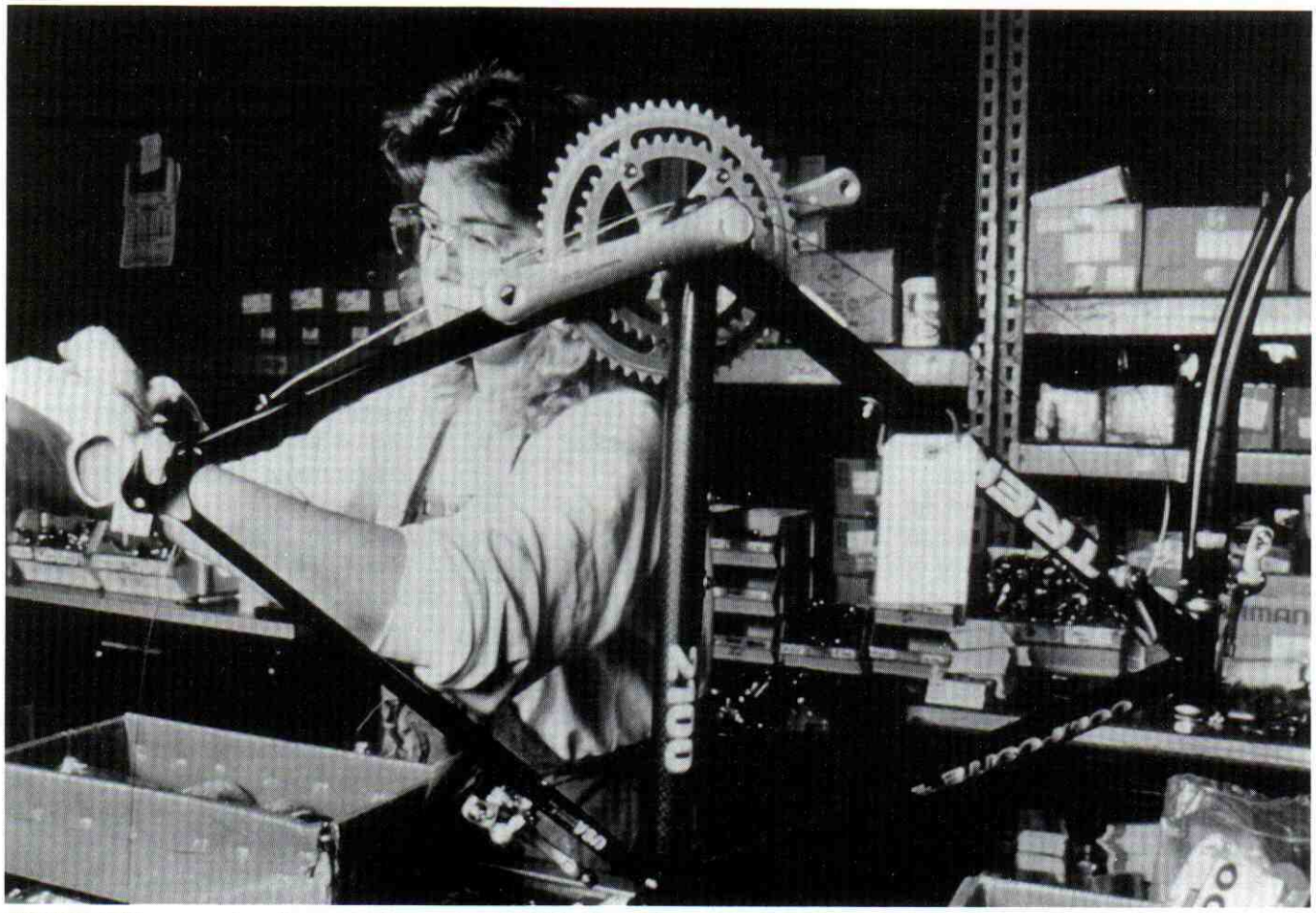


FIGURE 7. This woman is adding all of the parts of the bike to the frame. She does this at the shop where the bike will be sold. She can adjust all of the parts so that the bike is custom-made for the buyer. *Courtesy Trek® Bicycle Corporation.*

another person who must be paid for their work. On the other hand, the frame, wheels, and handle bars on the plastic tricycle are sent in a box to the customer, who puts it together at home. This saves the manufacturer the cost of assembly.

SUMMARY

Once again we notice that cost plays an important role in the design of a bicycle. Can you remember what other concerns the designer had to consider while building a mountain bike? Aerodynamics, balance, weight, and strength all needed to be kept in mind. In order to design a bike that best meets as many of these needs as possible, the designer uses the process of: 1. Thinking of an idea, 2. Planning a drawing, and 3. Making the design. It takes a lot of working and reworking of ideas, but in the end we have the bicycle that we have all been wanting. That is, until someone has a new need. Then we begin the design process all over again.

STUDENT QUIZ

1. Name the basic steps in designing.
   a. *(thinking of an idea)*
   b. *(planning a drawing)*
   c. *(making a design)*
2. Karl Von Drais invented the *(Draisine)*.
3. Match the word to the definition.
   a. working plans
   b. assemble
   c. aerodynamic
   d. profit

   1. moves easily through air
   2. the design on paper
   3. money you made
   4. to build

   (a-2, b-4, c-1, d-3)
4. If it cost you sixty dollars to build a bike, and you sell it for one

DESIGN BRIEF

Problem
To come up with a new idea for an attachment to hold something important, like a pogs' container, a backpack, a water bottle, or a flashlight on a bicycle like the one in the picture.

Objective
Create a new design for a bike attachment using the basic steps for designing.

Challenge
Think of an idea for a design. Make a drawing of your design, including a list of materials. Then, make a model of your new bike attachment using the materials given to you.

Materials & Equipment
Use cardboard, aluminum foil, plastic wrap, string, paper bags, and any items that you can recycle.

Glue, tape, rubber bands and staples may be used for joining.

Procedures
Just like Karl Von Drais, who built the Draisine, you are to build a new bike attachment for your bike. Use any and all the materials provided by your teacher. If he/she permits it, you may bring in other materials that can be recycled. For example, bring broken parts from toys or household items. Be sure to list all the materials that you used for your new attachment.

Example
List of Materials: empty match boxes, old toy parts, toothpicks, straws, coffee stirrers, glue, masking tape and transparent tape.

FIGURE 8. Look at this bicycle. Think of a way to attach something that you would need to carry along on a bike ride. *Courtesy Trek® Bicycle Corporation.*

hundred and twenty, what is your profit? *(sixty dollars)*

5. Cost will affect your design as you choose your *(materials)*.

POSSIBLE STUDENT OUTCOMES

- Name the three basic steps in designing.
- Identify the inventor of the bicycle.
- Calculate profit.
- Explain aerodynamics.
- Describe working plans.
- Give a definition for the word assemble.
- Explain how cost affects the materials to be chosen.

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T. Danae Thompson *and* **Martha Jacobs** *are guest authors for this article, both are elementary school teachers.*

This module was written as a result of numerous requests for Resources in Technology aimed at elementary students. Please send your comments and explain your interest in additional modules at this level.