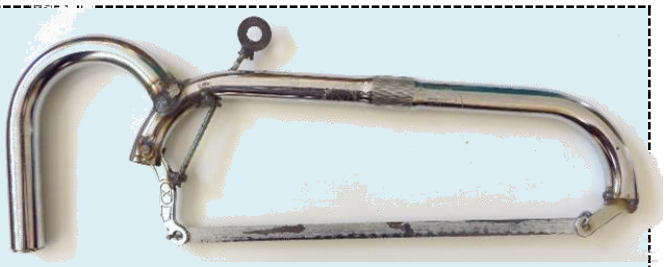
IDIN Skill Builder: Bicycle Hacksaw Instructor Guide

Time Needed:

5 hours total, or 2 x 2.5 hour sessions.



Number of People Needed to Run the Session:

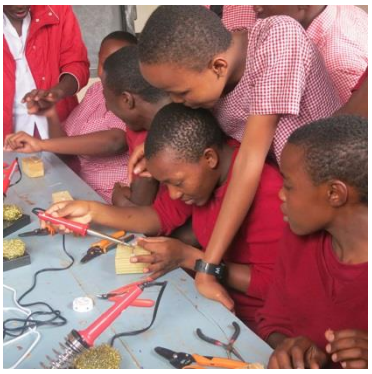
1-2 instructors per 6 participants.

Space Set-Up:

This should be done in a workshop that is equipped with table space, vices and welding equipment. It would be useful to also have an open space where the instructor can demonstrate steps to participants. The space should also have a safe welding area.

1. Introduction

PHILOSOPHY



Many people around the world go through their lives rarely using their inherent creative instincts to make a useful object with their own hands. However, a belief in one's individual ability to create technology can lead to a sense of agency and a belief that one can create positive change in the world. This idea embodies the purpose of a Skill Builder.

Those who participate in a Builder leave believing they can be creative, work with technology, and build tools to solve problems present in their own lives or in the lives of others. The experience provided is transformative; if they can successfully build this device, then by extension, they can build another. For example, creating light is a magical experience, endowing a person with the ability to replicate the power of the sun. As a person said in Zambia following a Builder, "I was a dull knife and you sharpened me."

This kind of transformation is only achieved by having participants build on their own terms, exploring the use of tools with guidance from an instructor. It is important that their devices work so they are successful and feel a sense of accomplishment; but even more important is that they felt they did it themselves and believe they could do it again.

Skill Builders are the building of a piece of technology as a means to acquiring fabrication skills, working with materials, and learning physical principles. This can range from using wire strippers and a soldering iron to create an LED light to using a hammer and chisel to shape wood into a spoon. The key to inspiring change in participants does not lie within the device created; it lies in the skills gained and the newfound sense of ability felt by participants.

For those who have never used the tools before, the initial stages of the Builder will feel awkward. Participants may "fail" at steps in the process. They should be guided out of these stumbles, not have the stumbles solved for them. Struggling with the process and resolving issues on one's own are important in building the feeling of agency that is necessary to use these skills to address problems in the world.

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Skill Builders are also a powerful experience for the instructors. When the participants have successful devices, the pride they have will be reflected in the pride instructors feel. The instructors are the first link in passing along the philosophy and skills transmitted. If the instructors are steeped in these principles, the participants will carry the philosophy and skills forward in their lives and will share with those around them.

GUIDELINES

To be an effective instructor and create a valuable experience for the participants, keep the following ideas in mind while delivering the Skill Builder.

- ☐ Allow participants to work through the steps at their own pace. It is important that everyone gets to practice using each of the tools. Since this is the first time most people have used them, it will take longer than you might expect. The length or number of sessions should account for this. If you find you still go over, arrange for more time.
- ☐ Encourage participants to form pairs and help each other through the activity. Ensure there is not a dominant person in each pair who does all of the tooling and machining.
- ☐ If a participant is having trouble, encourage those around him or her to provide help so the participants can learn from each other. When a participant has solved a problem, have them demonstrate the solution to the group so they can take credit.
- ☐ If a participant makes a mistake, help them to diagnose the problem and fix it. This should be done by encouraging them to share their thoughts on the problem and the solution, before offering your own diagnosis and solution. Avoid correcting the mistake for the participant except in extreme situations.
- ☐ It is important to practice showing, instead of telling. A visual demonstration goes much farther than an oral description of the task. During the Skill Builder, be vigilant to ensure there is more showing than speaking.
- ☐ Encourage participants to use spare materials to practice the skills before using the tools to make the final product.
- ☐ Observe and advise the participants on their technique in using the tools so they have the opportunity to improve.
- ☐ Complement the participants as they successfully complete steps in the construction process, emphasizing that they are responsible for accomplishing the task.
- ☐ Promote a sense of camaraderie in the group. Ways to do this can include a group picture, having each person sign each other's device, or taking time for each person to demonstrate their functional device. Place emphasis on each participant's success in creating a working device to increase their confidence.
- ☐ Keep the guiding principles described in the philosophy section in mind as you deliver the curriculum.

PREPARATION

To set the Skill Builder up for success, do the following ahead of time:

- ☐ Make the device yourself to discover what steps participants might find difficult and to ensure all tooling and machinery is functional.
- ☐ Set aside one set of Skill Builder parts for yourself and subassemblies to show key steps. As you lead the participants through the Skill Builder, you can demonstrate steps using your own set of parts.
- ☐ Set up at least one completed device that participants can reference as they complete the activity.
- ☐ Prepare extra material that the participants can use to practice skills.
- ☐ Print one 'Participant Skill Builder Photo Guide' per participant.
- ☐ Print one 'Skill Builder Module User Evaluation Sheet' per participant.
- ☐ Prepare supplies and tools at the work stations.
- ☐ Ensure a first aid kit is available.
- ☐ Ensure there are enough safety glasses for you and all participants to each have a pair throughout the activity. Ensure other personal protective equipment is available where necessary.

SAFETY

Below is a list of safety concerns relevant to this Skill Builder.

Welding:

- Welding emits ultraviolet light, which damages skin and eyes. A face shield must be worn to protect eyes. Safety glasses must be worn under the face shield. All exposed skin must be covered to protect from burns and hot flying metal. Specifically, thick leather gloves must be worn. Close toed shoes must also be worn. Last, clothing should be cotton, as synthetics burn easier.
- Welded pieces are incredibly hot. Extreme care must be taken when touching them. Recently welded parts must be held using pliers. Once the piece has cooled, it can be held with the leather gloves. Participants may sustain burns if these precautions are not followed.
- Electrocution is possible while welding. This will happen any time your body completes the circuit. Do not touch anything with bare skin. For example, if one bare hand touches the live piece while the other bare hand touches a ground source, the person will be electrocuted.
- The machine should be properly maintained. There cannot be any exposed wire. Welding cannot be done near water or any flammable gas or liquid.
- Never weld metal used to carry flammable gasses or liquids.
- Audibly inform people before beginning to weld so they know not to look. If they are not informed and look at the welding, their eyes will be damaged by the ultraviolet light.

Cutting:

- A sharper hacksaw blade is safer than a dull one. Using force to do the work as oppose to relying on the tool creates a higher risk situation.
- When cutting a material, the blade can jump and hit one's hand. It is important to keep body parts out of the direction of the blade.
- Cutting metal can create burrs, sharp, small pieces of metal. These should be carefully removed using a file. They can easily cut skin or may become lodged in the skin.

Drilling:

- When drilling, the material should be secured in a vice or securely attached to a work surface. The drill will cause a poorly secured material to spin, which can injure a participant.
- As with a hacksaw blade, a sharp drill bit is safer than a dull drill bit.
- A drill is powerful and can jump around if it is not gripped tightly. If it is moving around, it can easily hit a person.
- Drilling through metal can also create burrs. These should be carefully removed using a file. They can easily cut skin or may become lodged in the skin.

2. Overview

LEARNING OBJECTIVES

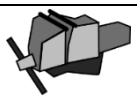
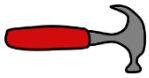
- ☐ Participants will learn how to manipulate metal pipe using a hacksaw, drill and several other hand tools, including a file, hammer and punch.
- ☐ Participants will learn how to properly cut metal.
- ☐ Participants will learn how to properly use a drill.
- ☐ Participants will learn basic welding skills.
- ☐ Participants will learn how to tension a hacksaw.
- ☐ Participants have made a working hacksaw.

LESSON PLAN

1. Explain the technology the participants are about to build. *10 min*
2. Complete pre-questions in the 'Build-It Module User Evaluation Sheet'. *5 min*
3. Prepare the hacksaw body. *30 min*
4. Prepare the blade tensioner. *1 hour*
5. Assemble the frame and tensioning system. *1 hour, 20 min*
6. Make the tensioning arm. *1 hour, 15 min*
7. Reflection and feedback. *25 min*
8. Complete the post-questions in the 'Build-It Module User Evaluation Sheet'. *15 min*

3. Materials

TOOLS

	Item	Quantity Per 6 Participants
	Hacksaw	3
	Vice	3
	Marker pen	3
	Flat hand file	2
	Round hand file	2
	Vice grips	2
	Pliers	2
	C-clamps	2
	Spanners for brake hardware	2
	Hammer	2
	Punch	2
	Welding machine	1
	Drill and bits (3/2” and according to the size of brake caliper bolt)	2
	Safety glasses	6

SUPPLIES

	Item	Amount	Cost
	Steel, drop-bar bicycle handlebar	1	$5
	Steel, side-pull bicycle brake caliper	1	$3
	12 mm hex nut	1	minimal
	10 mm threaded rod	150 mm long	$1
	10 mm hex nut	1	minimal
	10 mm washer	1	minimal
	12” hacksaw blade (24 teeth per inch, TPI)	1	$1
		Total Cost	**$10**

4. Teaching Notes

INTRODUCTION TO THE SESSION

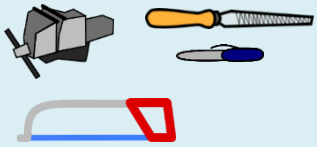
Hacksaws are an important tool in any workshop, used to cut steel and other metals. Hacksaws have several key sections: the frame, handle, blade and tensioner. These sections should be pointed out and described to participants. Their equivalent can then be pointed out on the bicycle hacksaw.

PREPARE THE HACKSAW FRAME

Skills

hacksaw

Tools



Supplies

1. The hacksaw frame should lie entirely in one plane. Mark the handlebar before the curve of the handle (as shown in the photo).

   Teaching note: This ensures that, in the final hacksaw, all force used to cut is applied in line with the blade.

2. Put the handlebar in a vice and cut the handlebar in the desired places using a hacksaw. Use a file to remove the burrs created by cutting metal.

   Teaching note: Explain to participants that tightening the vice too much risks deforming the tube. Show that using brass shims can help keep the metal pipe from getting deformed.

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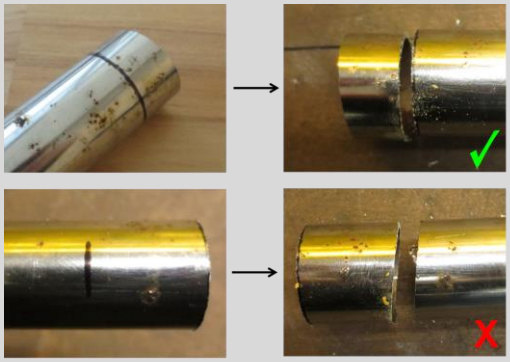
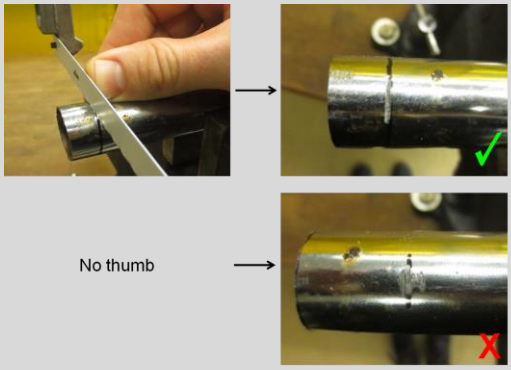
TEACHING NOTE: *DEMONSTRATE PROPER USAGE OF A HACKSAW*

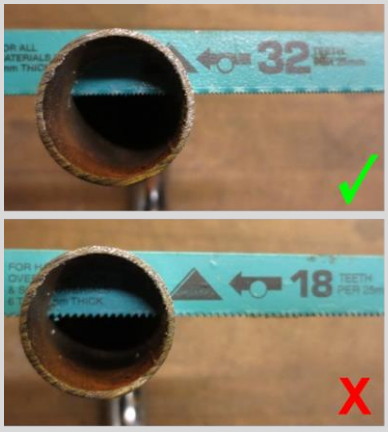
Mark the entire cut line. While using a hacksaw, the blade can drift and the cut surface may end up crooked. In order to watch whether the saw is travelling straight, it is important to have a line along which to measure. Therefore, draw a line across the entire piece you are cutting. As you use the saw, watch that you are following the line and make slight adjustments as needed.



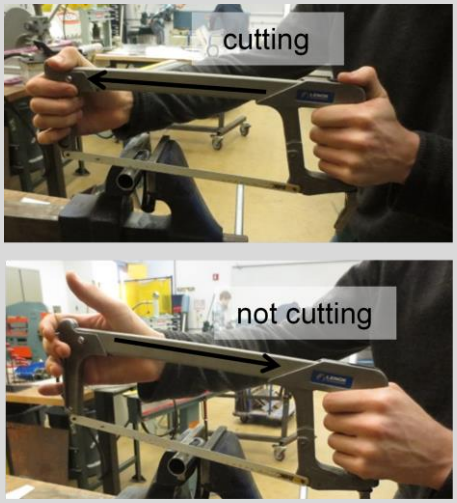
Use a thumb to stabilize the blade while initiating the cut. The most difficult part of using a hacksaw is initiating the cut. The smooth surface of the metal causes the blade to jump around. Place a thumb along the line where the cut is intended. Hold the blade against the thumb so that it travels in a steady, straight line. Make slow cuts so that the blade does not jump, using the thumb to continue steadying the blade. Once the cut is deep enough, the blade will not jump and you can hold the saw with both hands.



Let the saw do the work. Choosing a saw with the appropriate number of teeth per inch is important to using a hacksaw efficiently. More teeth per inch should be used on thinner material while less teeth per inch should be used on thicker material. For cutting pipe, more teeth per inch will make for a smoother cut and the blade will catch less.



The saw should do most of the work. Putting too much force onto the saw will make the arm tired but the material will not cut more quickly. Hacksaw blades only cut in a single direction, and should be oriented in the saw with the teeth pointing forward. Make the forward strokes with strength, but draw the blade back without using force.



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You now have three metal tubes. The long metal tube will be the body of the hacksaw and one of the shorter tubes will be used as the hacksaw handle.

3. Shorten the short tube to create the handle. The cut must be made so that the tube is the correct length to allow the handle to lie perpendicular to the alignment of the hacksaw blade.

4. Using a hand file, smooth the sharp edges of the cut tubes and shape the end you just cut so that it fits with minimal gaps.

5. You can now lay out the pieces to see the hacksaw taking shape.

LEARNING OBJECTIVES ACCOMPLISHED:

- ☐ Participants will learn how to manipulate metal pipe using a hacksaw and file.
- ☐ Participants will learn how to properly cut metal.

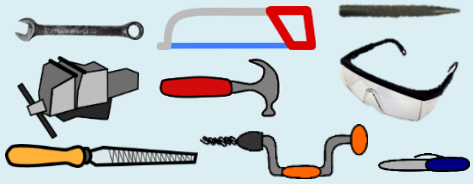
PREPARE THE BLADE TENSIONER

Skills

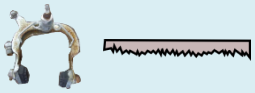
hacksaw

drill

Tools



Supplies

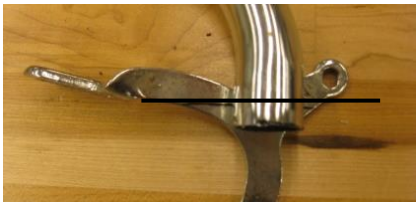


DISASSEMBLE THE CALIPER

6. Remove the nuts and bolts from the caliper using a spanner. Pull off the spring from the caliper using pliers. You should now be able to take the caliper apart.

7. Take the Y-shaped caliper arm and align it with the hacksaw handle. Once it's in place, draw a line about 12 to 25 mm above the end of the hacksaw frame so that you know where to cut the caliper.

   Teaching note: The caliper arm should be aligned so that it matches the curve of the main bar.

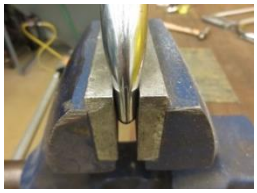


8. Put the caliper arm in a vice and use a hacksaw to cut it.

   Teaching note: It may be easier to cut if it is positioned vertically.

9. Flatten the end of the frame bar so that the caliper section can fit closely into the bar, and be easily welded later.

   Teaching note: You can flatten the end of the bar using either a hammer or by squeezing the bar gently using a vise. If using a hammer, hammer by switching sides of the pipe to compress the pipe evenly. It may be easiest to put the piece of caliper section in the pipe while compressing to know the width needed.



10. Cut and file down the edges of the caliper arm so that it can fit into the flattened tube. Hacksaw the pointed sections off, and then file until it fits closely in the bar.

    Teaching note: Continuously check the fit between each hacksawing and filing. These two parts will be welded later.

PREPARE THE BACK END TENSIONER

11. The u-shaped caliper arm will be used to make the holder for the other end of the blade. The section of the caliper arm with two holes (one centered, one on the end) will be used to create a pivoting arm that can hold the blade in place and be used to keep the blade under tension.

12. Saw off the end of the arm which is not required. Use a file to smooth the edges of the arm section so that it will be able to move around smoothly inside the bar.

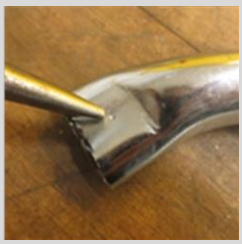
    Teaching note: This will be done most easily if the arm is held in a vise.

13. Like previously, you need to flatten the other end of the main body so that the caliper arm section can fit inside the body and pivot freely. Once the body is flattened, check that the caliper section fits, and file it more if required.


14. Drill into the end of the main bar for a bolt that will attach the caliper arm and allow it to pivot. Work out where the hole should be and use a punch to create an indentation in the correct position. The hole diameter should match that of the caliper bolt.


TEACHING NOTE: *DEMONSTRATE PROPER USAGE OF A DRILL*

Use a punch. Most metal surfaces are smooth. It is hard to get the drill to make a clean hole in the desired location because the drill will move around. To prevent this, use a hammer and a punch to make an indentation in the metal. Then, the drill bit will sit within the indentation and the hole can be successfully drilled.

Work your way up in size. It easiest to drill a large hole by starting with a smaller sized drill bit. The drill bit sizes should be increased incrementally by 50% each time until a hole of the needed size is made.

LEARNING OBJECTIVES ACCOMPLISHED:

- ☐ Participants will learn how to manipulate metal pipe using a hacksaw, drill and several other hand tools, including a file, hammer and punch.
- ☐ Participants will learn how to properly cut metal.
- ☐ Participants will learn how to properly use a drill.

ASSEMBLE THE FRAME AND TENSIONING SYSTEM

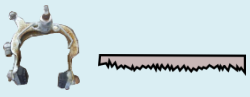
Skills

hacksaw

welding

Tools

Supplies



ATTACH THE FRONT END TENSIONER

15. Use a grinder, file or sand paper to grind the bar's chrome coating away in the areas where you want to weld.

    Teaching note: You want to remove the chrome as it gives off unpleasant gases if heated.

16. Position all of the pieces to ensure the device will fit together. Make marks on the pieces to indicate where it should be welded.

    Teaching note: Depending on the length of the pieces of the brake caliper, the blade may be too short to fit between the two ends of the hacksaw body. If this is the case, cut an extra piece of caliper arm. Weld that piece to the one already on the right side of the hacksaw body to extend that section of the frame.

17. Fixture, tack and weld the front caliper arm onto the main bar.



TEACHING NOTE: *DEMONSTRATE PROPER TECHNIQUE IN BASIC WELDING*

Fixturing. In order to make sure the parts are welded in the desired location and orientation, they should be fixtured first. In other words, the parts need to be secured to the work surface and each other such that they cannot move when the welding begins.


Tacking. An initial weld, or tack, should be made to lightly secure the two pieces together. Tacking allows the welder to check that the pieces were connected in the desired orientation. If they were not, breaking the tack allows the welder to try again. A tack can be broken by hand.

Managing the current. If too much heat is applied to the welding area, the welded material can burn through. This will occur if the current setting is too high on the welding machine, if the welder dwells on one area of the weld for too long, or if the electrode is angled towards a sharp edge. The chance of this occurring is increased when the material is thinner.

18. Fixture, tack and weld the handle onto the main bar.



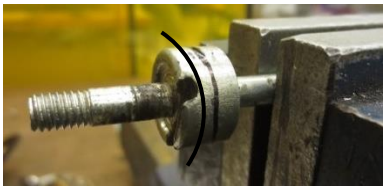
FASTEN THE BLADE

19. To fasten the blade, cut the two rings from the spring using a hacksaw.

    Teaching note: After cutting, put the spring in a vice, and spread the spring open slightly so that it can fit onto the hacksaw arm. (however be careful as the metal is a fairly high strength and would be easy to break or deform).

ATTACH THE BACK END TENSIONER

20. Take the long bolt from the section of caliper parts and cut it in half to create the pivot screw.



21. Use a file to smooth the top of the cut screw.

LEARNING OBJECTIVES ACCOMPLISHED:

- ☐ Participants will learn how to manipulate metal pipe using a drill, hammer, punch and file.
- ☐ Participants will learn how to properly cut metal.
- ☐ Participants will learn how to properly use a drill.
- ☐ Participants will learn basic welding skills.

MAKE THE TENSIONING ARM

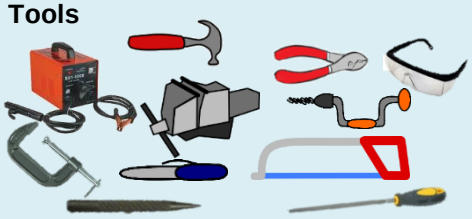
Skills

hacksaw

drilling

welding

Tools



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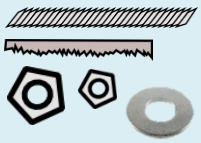


22. Fixture, tack and weld the large, 1/2” nut onto the front end tensioner. The nut should face the hacksaw frame. It should be positioned such that the threaded rod will be close to vertical when it is sitting in it.


23. Position the threaded rod to mark the holes for drilling through the hacksaw frame. A mark should be made on the top and bottom of the frame.

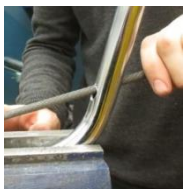

24. Place the hacksaw frame into a vice grip. Use a punch and hammer to create an indentation at the desired locations for drilling.

25. Drill through the frame from the top and bottom separately. Once the holes are at the size of the threaded rod, fix the hacksaw frame in the vice such that the holes are vertical. Drill through again.

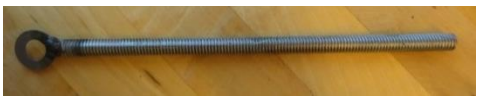


26. Check whether the holes are properly aligned by inserting the threaded rod. If they are not, use a round file to adjust the holes.

    Teaching note: As with the hacksaw, a file only works in one direction.


27. Weld a washer onto the threaded rod to make it easier to tension the hacksaw. The threaded rod can be cut shorter if necessary. Put the small nut onto the threaded rod and put the rod through the holes.



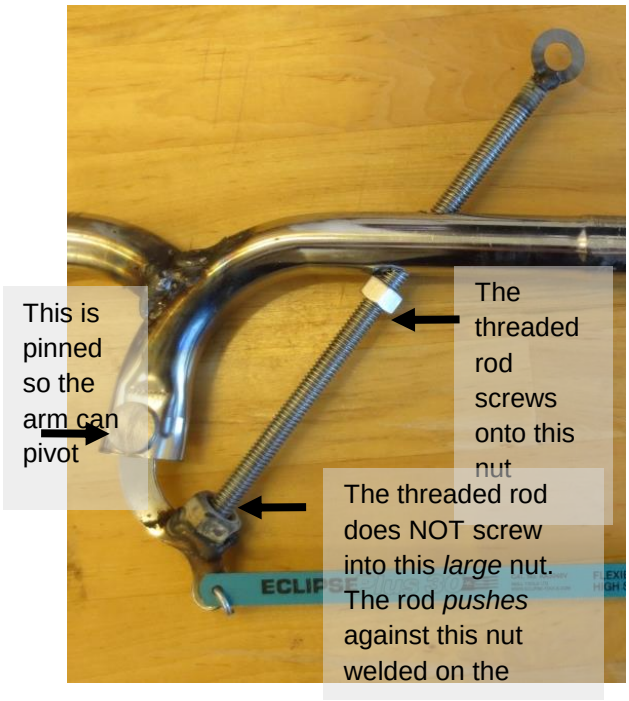
28. Assemble the final hacksaw.

LEARNING OBJECTIVES ACCOMPLISHED:

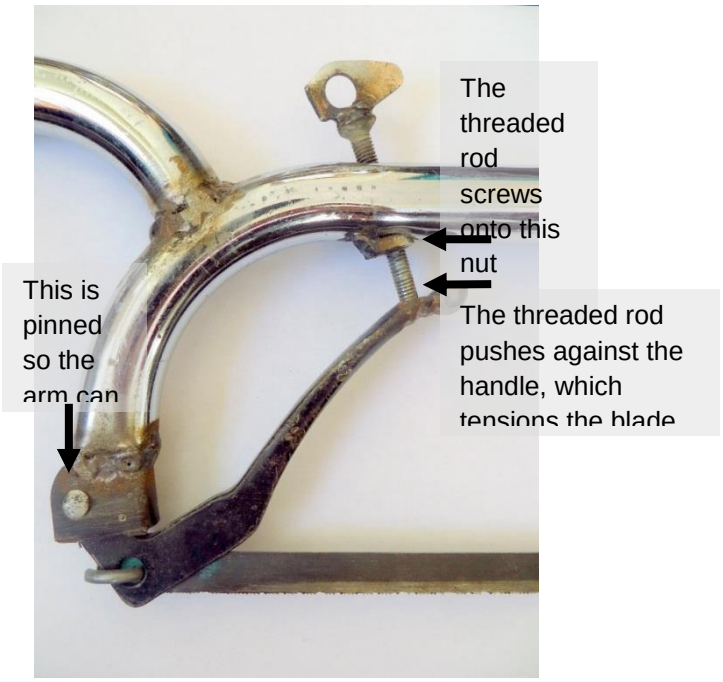
- ☐ Participants will learn how to manipulate metal pipe using a drill, hammer, punch and file.
- ☐ Participants will learn how to properly use a drill.
- ☐ Participants will learn basic welding skills.
- ☐ Participants will learn how to tension a hacksaw.
- ☐ Participants have made a working hacksaw.

DESIGN VARIATION

There are a few variations of how to make a rear tensioner, each using different parts of the bike.



Tensioning system, as shown in this Build-It using a caliper arm



Tensioning system, not shown in this Build-It using a brake handle. **This tensioning system, discovered later, seems to be a more robust design.**

REFLECTION AND FEEDBACK GROUP DISCUSSION QUESTIONS

- What would you make with your hacksaw?
- Besides another hacksaw, what would you make with the new skills you've acquired?
- Which skill that you learned are you most excited about?
- Which skill that you learned would you like to have spent more time practicing?

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