PROFILE BOATS

A hands-on boat-building STEM project

by **Rhonda Cummins**
Coastal and Marine Resources Agent for
Calhoun County
Texas Sea Grant College Program/Texas A&M AgriLife
Extension Service

This STEM project was created through an educational partnership between the Inteplast Group in Lolita, Texas; Our Lady of the Gulf Catholic School in Port Lavaca, Texas; Texas A&M AgriLife Extension Service in Calhoun County, Texas; and the Texas Sea Grant College Program.

DISCLAIMER:

- I am an amateur boat builder. I have tested the design as you see it presented on these pages, using the materials I have listed. I accept no liability for any loss or damages sustained during your construction or use of these instructions.
- Texas Sea Grant, Texas A&M AgriLife Extension Service, their partners and collaborators are also not liable for any loss or damages as you freely choose to use this information.
- If you have previous experience with different materials and methods, feel free to make your own changes to fit your specific needs or circumstances.
- These plans are not for commercial use.

The members of Texas A&M AgriLife will provide equal opportunities in programs and activities, education, and employment to all persons regardless of race, color, sex, religion, national origin, age, disability, genetic information, veteran status, sexual orientation or gender identity and will strive to achieve full and equal employment opportunity throughout Texas A&M AgriLife.

Publication supported in part by an Institutional Grant (NA18OAR4170088) to the Texas Sea Grant College Program from the National Sea Grant Office, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

TAMU-SG-18-401 July 2018

Sea Grant Texas AT TEXAS A&M UNIVERSITY

TEXAS A&M AGRILIFE EXTENSION

INTEPLAST GROUP

Mariners

INTRODUCTION

Using hands-on activities to teach students math and science concepts engages their senses and increases their understanding and ability to learn. Building small boats is one exercise that can be both fun and educational.

This project is designed to teach students math and science objectives, help them develop team-building skills, and provide practical experience building and paddling their own pram, which is a boat similar to a kayak but with squared ends.

Additionally, this activity allows students to:

- practice important life skills including using tools, reading plans, and following instructions,
- apply several mathematical concepts and review mathematical vocabulary,
- develop deductive reasoning, critical and creative thinking skills, and communication skills, and
- increase confidence in their own abilities when faced with new challenges.

This project is also about getting youth out on the water to have fun!

AN INEXPENSIVE WAY TO PUT STUDENTS ON THE WATER

Cost per unit are $30 and up, depending on local prices of material.

- A single-occupant boat can support up to 260 pounds.
- Lightweight: Each completed boat weighs approximately 15 pounds.
- Dimensions:

  - 46"x 26" x 7" (folded for transport or storage)

  - 7'6"x 26" x12" (unfolded and assembled for use)
- Originally based on a free Ken Simpson design, available at https://www.portableboatplans.com/cpb-1.php.
- This book also includes instructions for a kayak-style paddle.

It is strongly recommended that you read all information before starting the process.

GENERAL NOTES:

- This instruction book is written to guide the teacher through the project.
- Adults and students who fold **origami will have a definite advantage.**
- **You may wish to have students bend some cardboard to see how it folds before they try bending the plastic Profile Board. The direction of the corrugation affects the way the material will fold. It is important that the boat folds where YOU want it to fold.**

The students will only need three pages with boat plans (pp. 9-10) and the diagram for the interior framework (p. 7).

- If you are working with multiple students, it is highly recommended that you have all parts cut and drilled prior to starting the project.
- This process has been successfully used with students aged 9 to 14 years old.
- **It is strongly recommended that you read all information before starting the process.**

MATERIALS LIST
(PER BOAT AND PADDLE COMBO)

- 1 full sheet 4'x 8' (48"x 96") of 4mm Profile Board
- 23"x 48" 8-10 mm Profile Board[1]
- 28' of ¾" PVC pipe[2]
- 4- ¾" PVC tees
- 4- ¾" PVC 90° elbows
- 5-gallon plastic bucket[3]
- 8' small rope or cord
- 4 to 6 shoelaces
- Waterproof tape
- Fasteners (see below)

FASTENER LIST
(PER BOAT AND PADDLE COMBO)

- For boat, 8 each of:
  - ¼" x 2" machine screws
  - ¼" x 1-¼" fender washers
  - ¼" nuts with nylon insert
- For paddle, 4 each of:
  - ¼" x 1-½" machine screws
  - ¼" nuts with nylon insert

[1] If thicker Profile board (commonly called Coroplast) is not available, you can use 2 layers of the 4mm board or thin plywood. I recommend painting any wood so it does not absorb water. This piece becomes the floor of the boat and distributes the weight across a larger area.

[2] Preferably get one PVC joint so the bell-shaped end can be used as the connector for the paddle. If not, you will need a ¾" coupler, which does not work as well as the joint.

[3] A single bucket will make 5 paddle blades (i.e., 2 ½ kayak-style paddles).

General Notes:

- ¼"-20 fasteners are preferred, but other sizes (#8 or #10) will work. You may need to use other sizes based on availability in your local stores.
- Bolts will also work. Make this choice depending on the tools you have available (like the number of wrenches).
- Zinc fasteners may be preferable because of cost, but be aware that they will eventually rust.

TOOLS NEEDED

All you need are basic hand tools:

- Yardstick to mark measurements on the plastic and use as a guide for scoring[4]
- Screen tool or Allen wrench
- Measuring tape
- Phillips head screwdriver
- 7/16" wrench (or whatever you need to fit the size nuts you have chosen)
- Utility knife (easily cuts the profile board)
- Drill with 9/32" bit (or other size based on diameter of fasteners)
- Jigsaw (for cutting bucket into paddle blades)
- PVC pipe cutter

If you are only making a couple of boats, a hand drill and the cutters will work fine. However, if you are making several boats, it helps to use a drill press and a miter or chop saw.

[4] Scoring is the process of rubbing a weak spot in the plastic, allowing it to bend and fold. This creasing or crushing along the lines should not cut or punch through the plastic. A blunt tool is needed. Allen wrenches worked well for me. A plastic screen inserting tool was also used successfully.

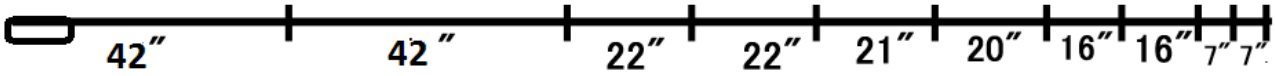
PVC CUTTING GUIDE

This guide can be given to a volunteer to pre-cut all your PVC parts with minimal waste.

This can also be used as an answer key if you want the students to create a guide.

PVC Cutting Guide

20' joint

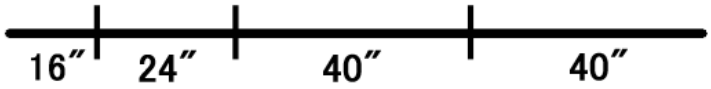


two 42" pieces for paddle shaft

Keep joint attached.

others for interior frame

10' stick



Bow **Stern** **interior frame**

*Image not to scale

If you can only find 10' sticks:

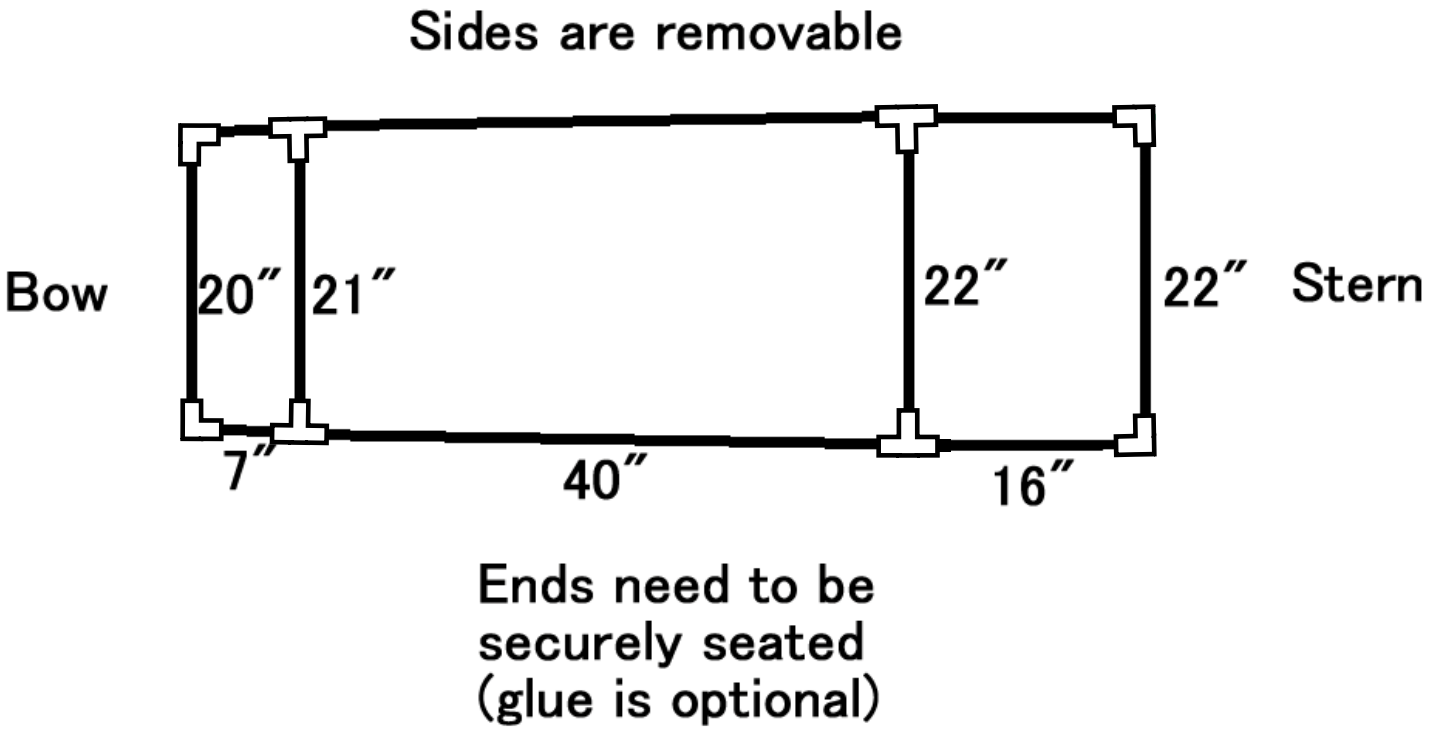
42 + 42 + 22 + 7 + 7 = 120 inches
and
22 + 21 + 20 + 16 + 16 = 95 inches

Note: you only need 28' of pipe.
You will have 2' left over.

Give each student a copy of this page.

INTERIOR FRAME

PVC pieces are used to give the boat structure. The 40" long pieces are taken out of the frame when folding the boat up for travel or storage.



**Images not to scale*

DRILL GUIDE

This guide can be given to a volunteer to pre-drill all your PVC parts.

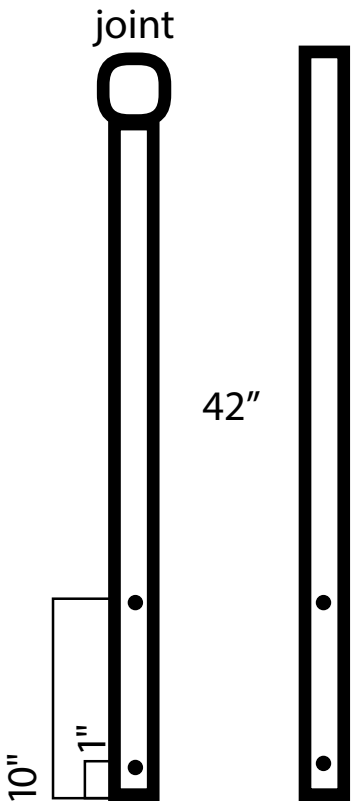
Measuring from the end of the pipe, the bow and stern holes are ***2" and 4"*** *from each end.*

Drill holes all the way through the PVC pipe. Line them up as straight as possible. (A drill press makes this easier.)

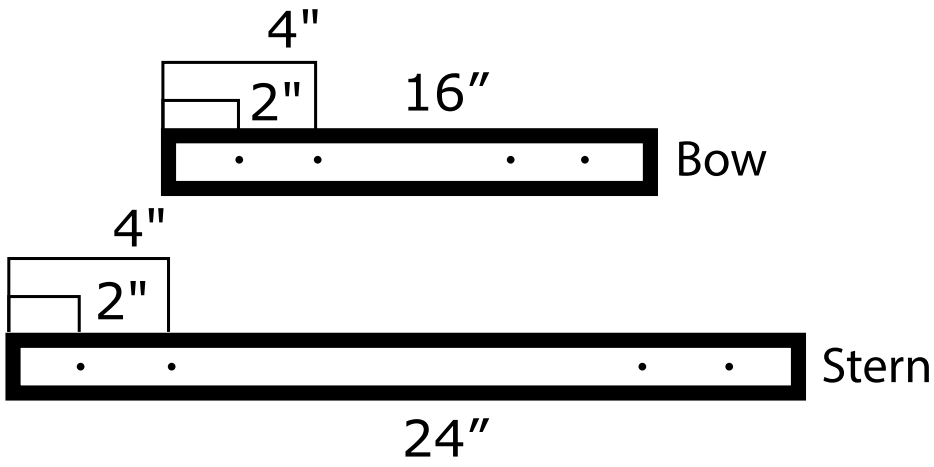
On the paddle, drill holes ***1" and 10"*** *from the end.* **Do NOT drill holes on the end with the joint.**

General Notes:

- When reading boat plans, some numbers are not written to keep the diagram from being too crowded.
- **The boat should be symmetrical when completed.** Make sure both sides of the stern are the same, and both sides of the bow should also match.
- Students can use simple math to fill in missing numbers if needed or desired.



Paddle shafts



Give each student a copy of this page.

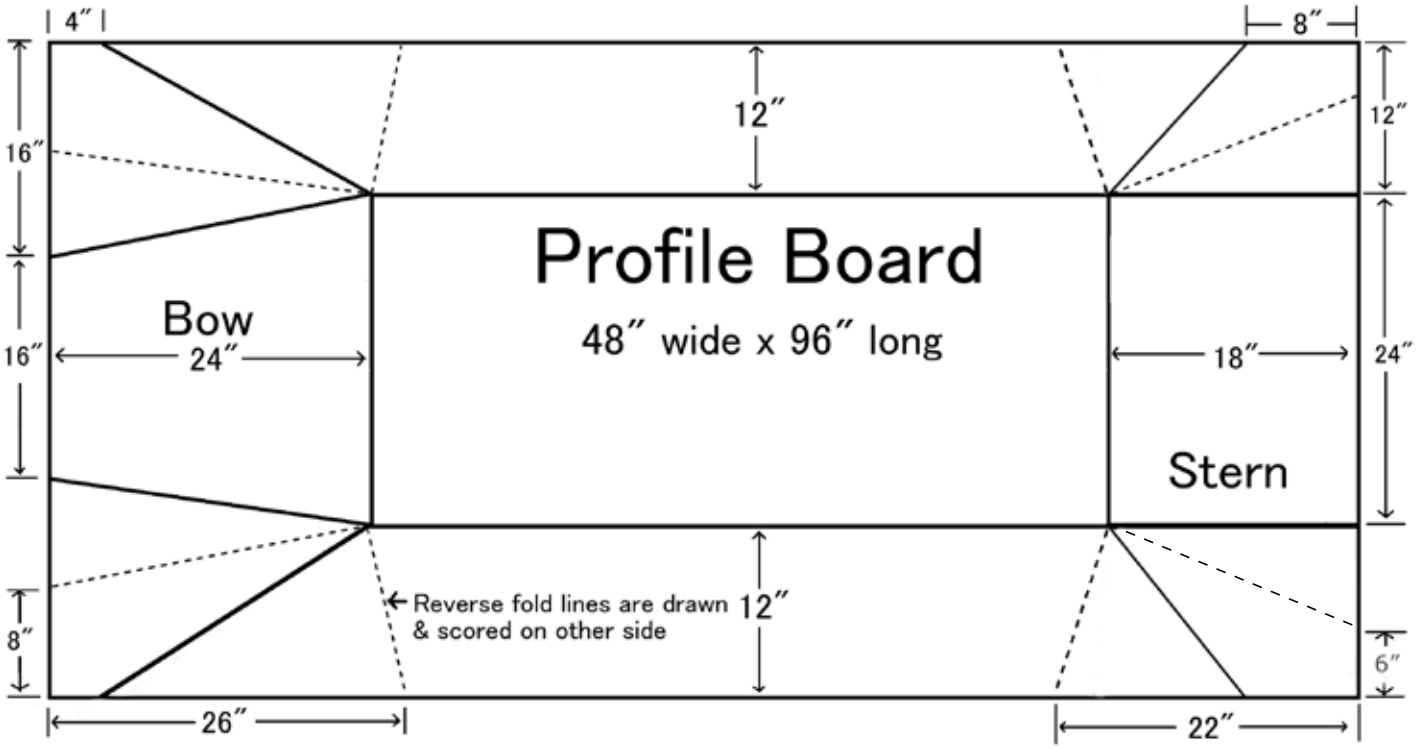
BOAT PLANS

All lines should be marked on the plastic prior to scoring.

This diagram has the measurements for <u>the top of the plastic.</u>

It is **<u>best to draw the inside rectangle first</u>** since all other lines connect to those corners. It is important to use the edge of the sheet for all outer measurements.

It is best to draw and score reverse folds on the opposite side. (See next page.)



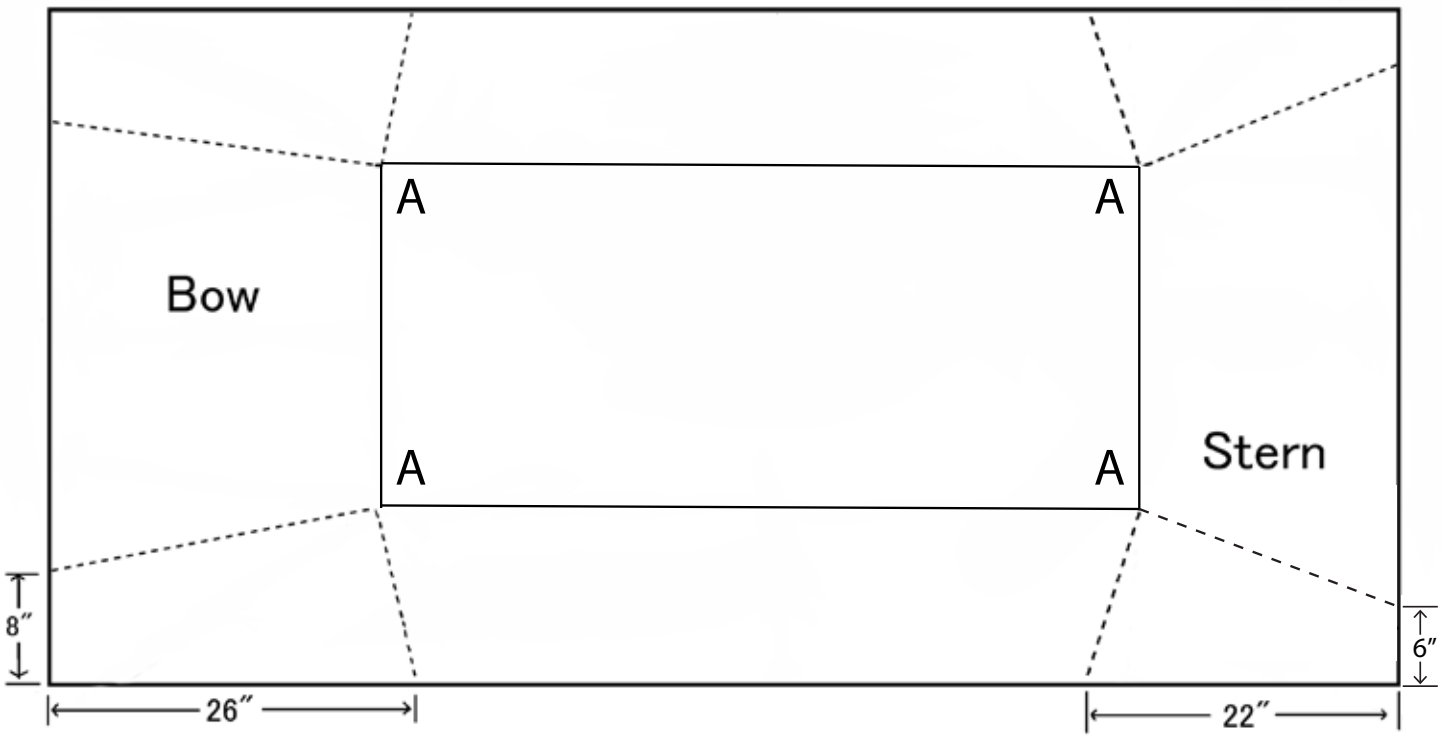
BOAT PLANS

Reverse folds are done on the <u>bottom side</u> of the plastic.

After drawing, scoring and bending the solid lines on the top side of the plastic, you should be able to see where the corners (A) of the inside rectangle are on the bottom side of the plastic.

Using the corners and the outside edge of the plastic, draw 8 more lines (dotted lines below), score and bend.

Give each student a copy of this page.

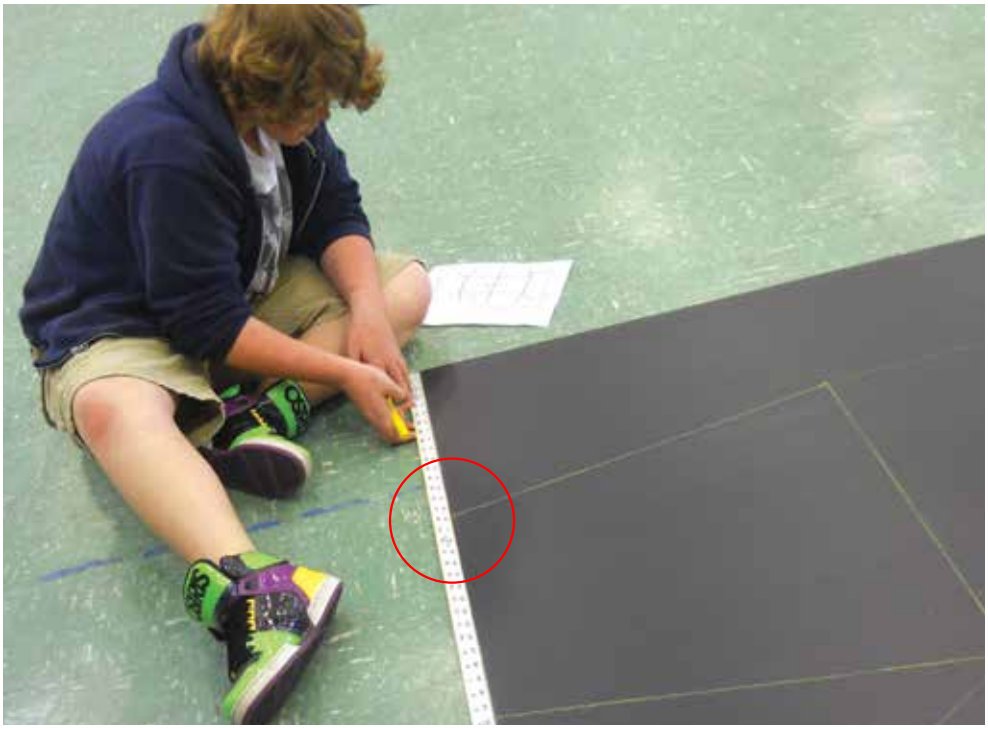


Step #1

- Lay the profile board on the floor.
- Using a yardstick and pencil, transfer the lines from the boat plans to the top side of the plastic.

It is best to draw the inside rectangle first since all other lines connect to those corners.

Check for accuracy before moving on to the next step. **Markings are made on the outside edge** for endpoints of the fold lines.



Step #2

It is important not to cut through or punch holes in the plastic during this step.

- Score (crease) the solid lines drawn on the top side of plastic.

It helps to use the yardstick or a piece of wood to guide your scoring tool. The wood shown above is a 2’ long 1" X 3" piece left over from another project.

Step #3

After all solid lines are drawn and scored on the top side of the plastic, these lines need to be bent.

- Start on the bow and bend all corner lines first.
- Bend the inside rectangle last.
- Expect the folds perpendicular to the “straws” at the bow and stern to be the hardest ones to bend.
- It helps to use a piece of wood to support one side of the crease while you bend the other side.
- If the plastic does not bend easily along the line, more scoring is needed.

Step #4

After bending the first folds, you can see where the corners of the inside rectangle are on the bottom side of the plastic.

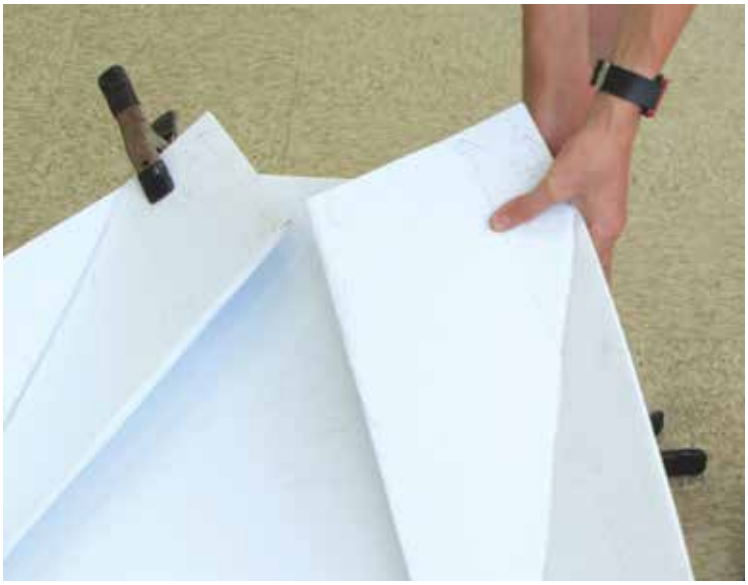
- Mark these corners with pencil.
- Use the second boat plan page to mark the reverse fold lines.
- Score those 8 lines and then bend them.

Step #5

It is time to make the boat 3-D.

- Turn the plastic so the top side is facing up and carefully work the folds to bend the plastic into place.

If you are familiar with origami, think mountain and valley folds.



Spring clamps are helpful if you have some.

Step #6

Permanently attach the bow and stern PVC pieces.

- Drill through the PVC holes to puncture the plastic. Insert the screw and secure with nut. **The washer must go next to the plastic.**

The drill bit is sharp. **Watch your fingers!**

Three layers of plastic are attached to the PVC piece with the fasteners.

Step #7

Install the 23" X 48" floor of boat. If you are using profile board, tape the edges with the open “straws” to keep them from filling up with water.

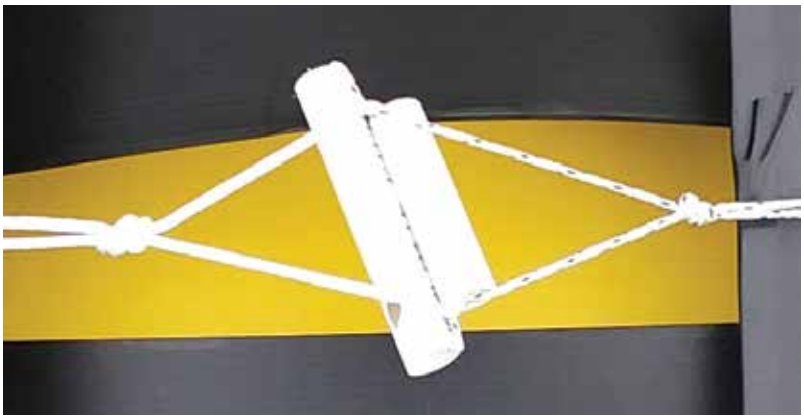
- Tape other open air spaces on both ends of the boat hull.

Step #8

Create interior frame (skeleton) using the plan on p. 7.

- Tie frame about 2" from the top on the sides with 4 shoelaces[5] (or pieces of small rope).
- A screwdriver can be used to punch the holes for the shoelaces to go through.

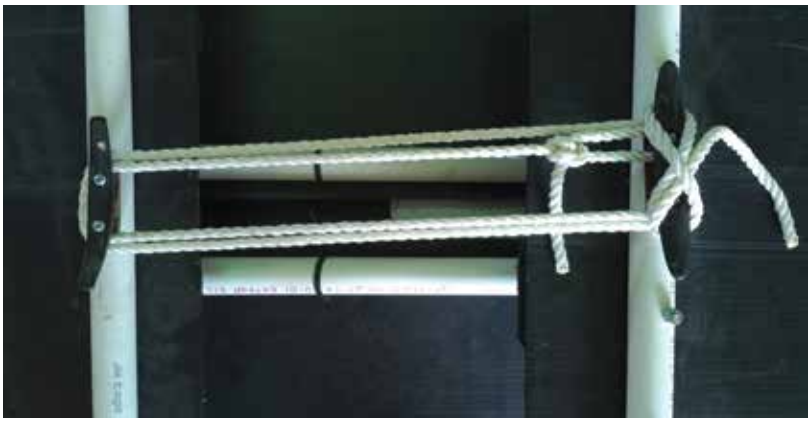
[5] Shoelaces are perfect since they are pre-cut with ends designed to go through small holes.



Finishing touches

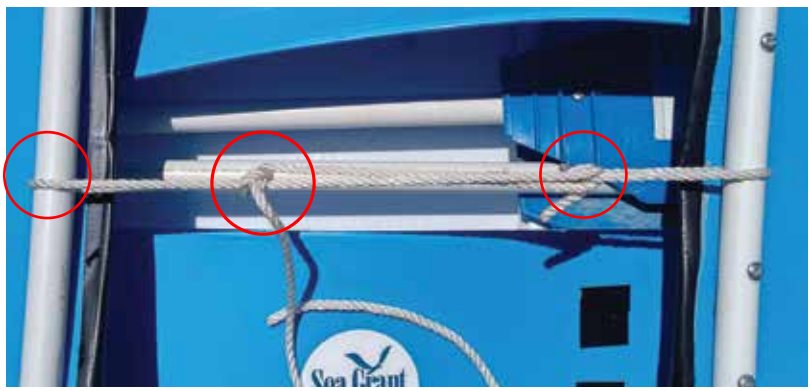
You must have a way to tie the boat

Toggles can be made from PVC and rope. The larger section is passed through the “y” of the smaller one.



If available, small cleats can be used with about 6’ of rope.

The simplest way is to use about 6’ of rope and tie a bowline around the bow.



Then loop back under stern piece, go back through the loop at the bow and tie off.

This should be done carefully by an adult.

together for traveling and storage.

Making the paddle

Blades are cut from a 5-gallon plastic bucket with a jigsaw. Divide the circumference of the bucket into 5 roughly even segments.

Paddle blades need part of the bucket bottom for strength.

Paddle continued

A miter saw makes it easy to shape the blades, but a jigsaw can also be used. Shaping both ends helps water drain out of the blade and produce less drag. Please note: This paddle design does NOT float.

Real kayak paddle blade

Drill holes in the paddle blade by going through the pre-drilled holes in the PVC shafts.

Attach the blades with screws and nuts.

Bell-shaped end joins two shafts together to complete the kayak-style paddle.

READY FOR TRAVEL!

To fold the boat for travel:

- Untie the shoelaces.
- Remove the 40" PVC side pieces from the bow and stern sections.
- Lay all parts flatly on bottom.
- Fold sides of the boat in first.
- Fold bow and stern to center.
- Tie ends together using chosen method.

WRAP UP

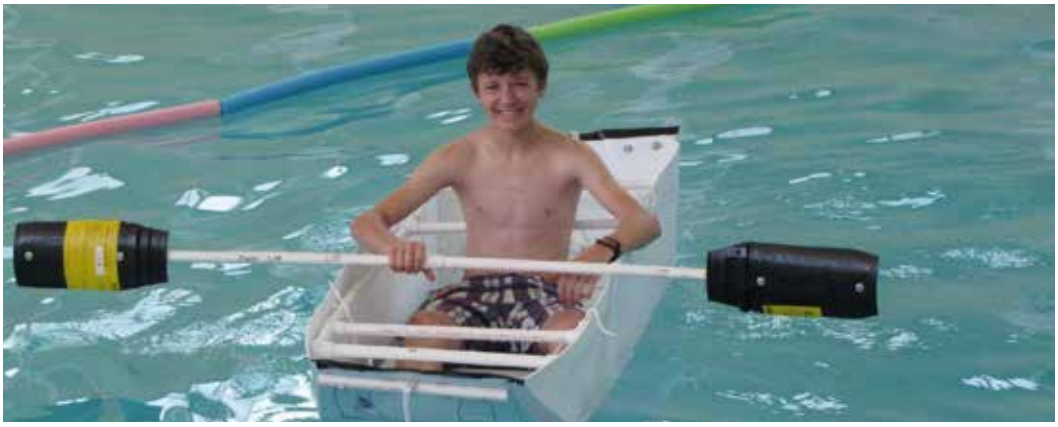
Take students to test their efforts in any calm water. The students can:

- Unfold the boat.
- Snap the frame together.
- Tie the frame in place.
- Put the paddle together.

Students should step down quickly into their boats and sit in the center of the floor.

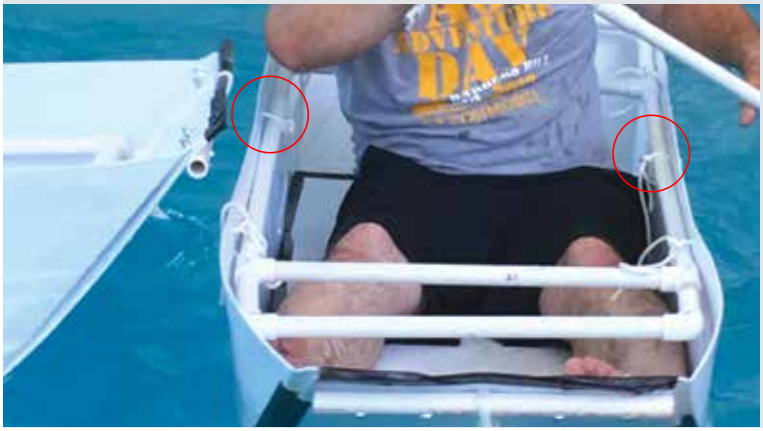
If there are no sharp rocks to puncture the boats, students have been able to self launch.

MAIDEN VOYAGE!



Swimming pools are a great place to launch.

So are ponds. Note that lifejackets should be used on the open water.



Special Note:

- Use a thicker floor board for heavier students (and adults).
- Heavier people will also need additional ties to hold the plastic to the interior frame to prevent the sides from buckling outward.

FINAL THOUGHTS

There are many possible variables involved in conducting this project, including but not limited to:

- Availability of parts, tools, and volunteers
- Time and timing, from multiple class periods to a day-long camp (It takes roughly 6 hours to build a group of boats with students.)
- Money for materials
- Number of students working at one time
- Number of adults working with the students
- Amount of work done in advance

We have tried to correct the small problems we encountered building more than 100 folding prams with students. However, each group is different, and you may still need to make minor adjustments to fit your situation.

It is highly rewarding for kids to use their own hands and minds to make something from nothing. I hope these instructions will help you and your group reproduce this project without great expense or confusion. If you have questions or need further details, please email me at rcummins@tamu.edu.

ACKNOWLEDGEMENTS

A project like this does not happen overnight. It takes several attempts to improve on the boat design and create this instruction manual. It takes many people, working together with several sets of youth to test the concepts. While I may have initiated this effort, I did not accomplish this alone. I would like to say a special thank you to the following individuals:

Ken Simpson
Don Nemetz
Charlie Jones
Jack LaBarge
Theresa Dent
Karen Lyssy
Sherrie Brown
Susan DeLaGarza
Pam Bales
Katherine Dent
Kayla Meyer
Terrie Looney
Larry Looney
Larry Kelley, Jr.
Michael Riviere
Tyler Fitzgerald
Monica Olivier
Samantha Humphrey

And of course, all the students and their parents.

TTI.TSG1814.5207.0718