BOAT BUILDING AND TESTING AT Washington Liberty High School

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Senior project design class

Washington Liberty High School

Arlington Virginia

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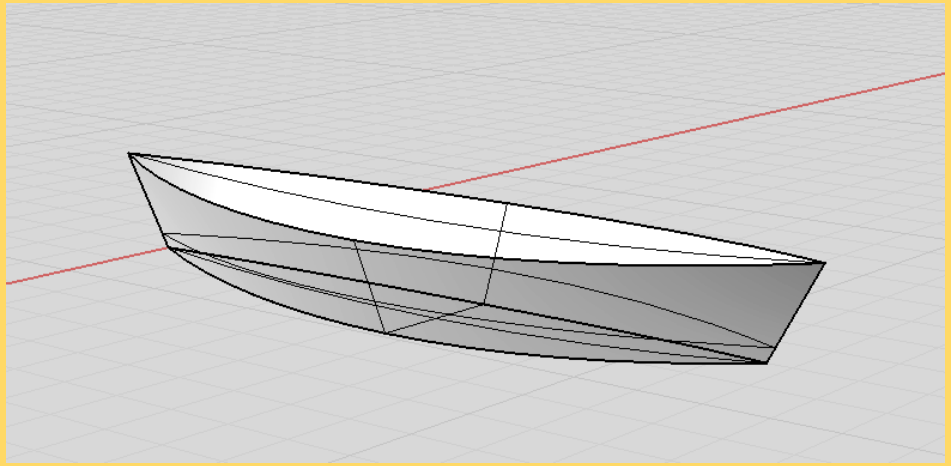
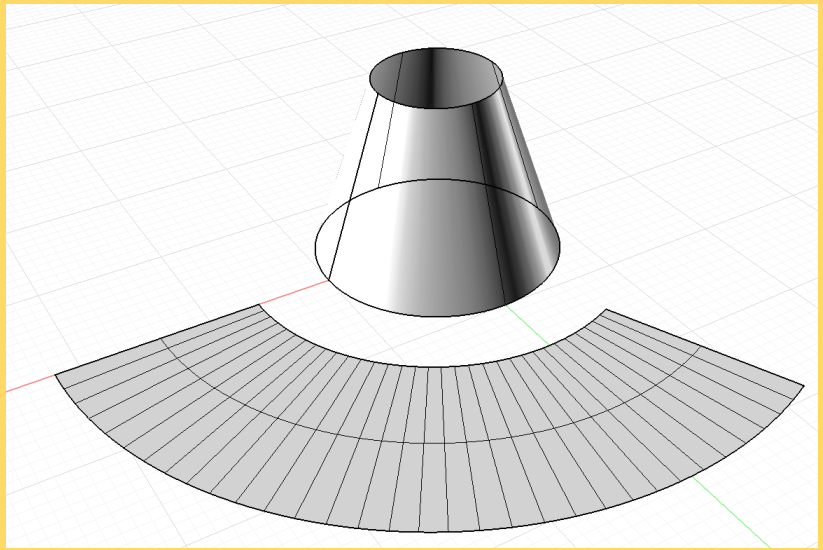
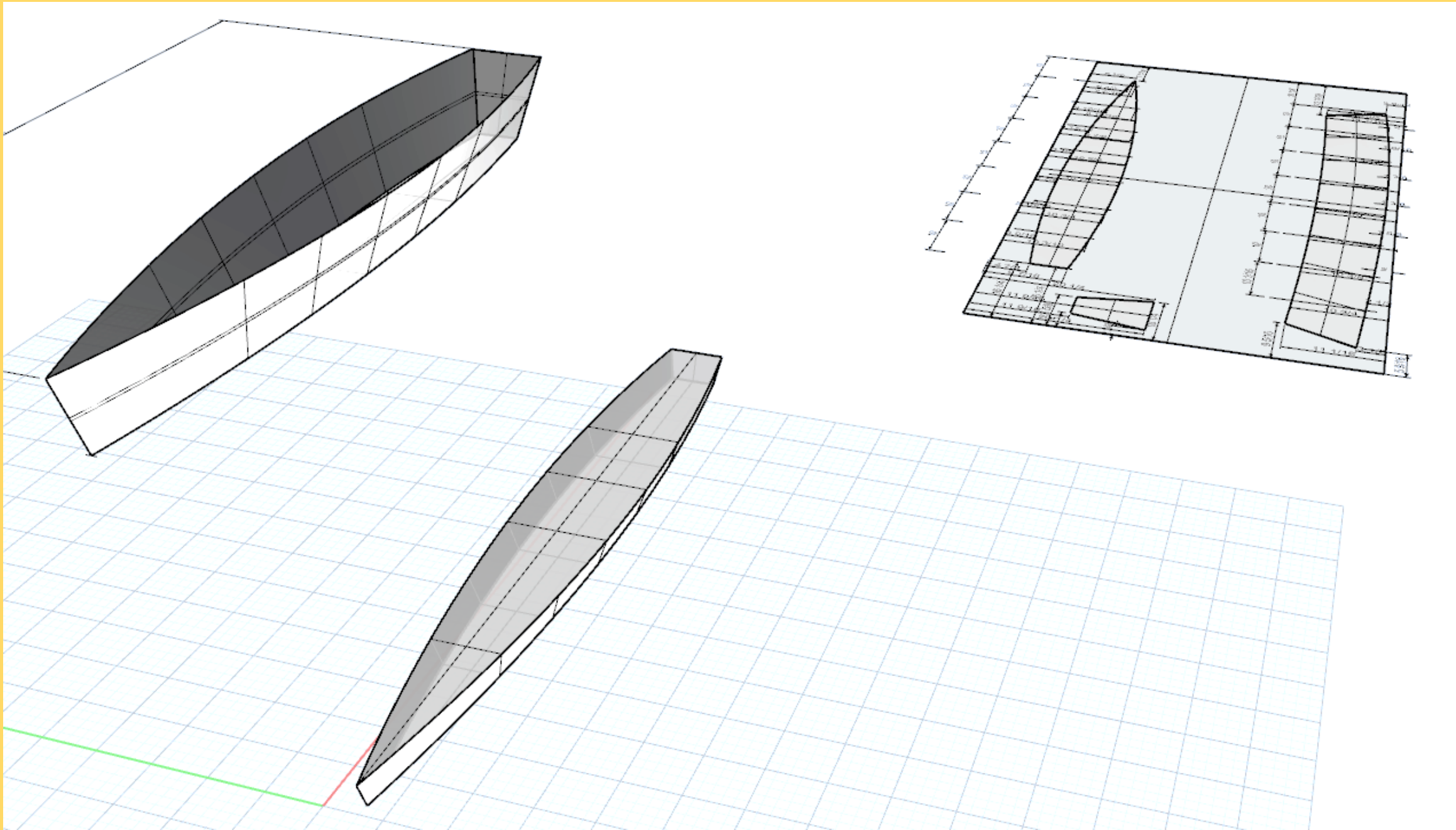
Developable surfaces

- The curved surfaces of our boats are called developable surfaces
- That surface has curvature in only one direction
- “For every point on the surface, a line on the surface passes through it”
- A cone is a good example





Boats designed with Rhino



Rhino Cheat Sheet For Building Our Boats Vers1 Nov 9 2017

1. Start in top view, set osnap on, set project on, set grid snap on to place a point at the origin of the xy plane
2. Turn grid snap off, turn point and end snaps on
3. Start the deck profile curve with curve, freeform, interpolate. Start with the bow, origin point, then pick profile points to make a deck curve from a top view. End at around x=60-90 inches. For a canoe, stern point should be at y=0. For transom stern, 0<y<max beam. If you don't like the top deck profile, delete it and start over.
4. Mirror the deck curve about the x axis: transform, mirror, and select deck profile, then enter. Start mirror point at bow, end somewhere on the x axis.
5. Start bottom profile curve with curve, freeform, interpolate. Stay in top view. Start with the bow, origin point, then pick profile points to make a bottom curve from a top view. It must be inside the deck profile. The bow and stern points can be inside or outside the deck bow and stern, but unusual boats can result.
6. Mirror the boat bottom as done to the deck in 4.
7. Move the boat bottom below the deck by 10-20 inches. On the top view, transform, move, and hit enter. Then switch to the front view, turn on grid snap, then move from z =0 to a negative value of z representing the height of the boat.
8. Place straight lines from the deck to the bottom at the bow and the stern. Curve, Line, Single line, Pick off the end of the profile curves.
9. Make one of the side surfaces. Go to perspective view. Surface, Sweep two rails, pick deck and bottom for the two rails, on the same side of the boat. Pick the bow and stern connecting lines for the crossection curves. Hit enter.
10. Either mirror the side surface, see 4. Or create the other side surface repeating 9.
11. Make bottom surface using sweep two rails, pick the two bottom profile cuves.
12. If there is a transom, make the transom surface using surface, planar curves, sweep 2 rails, or edge curves.
13. Hull is done.

Design requirements

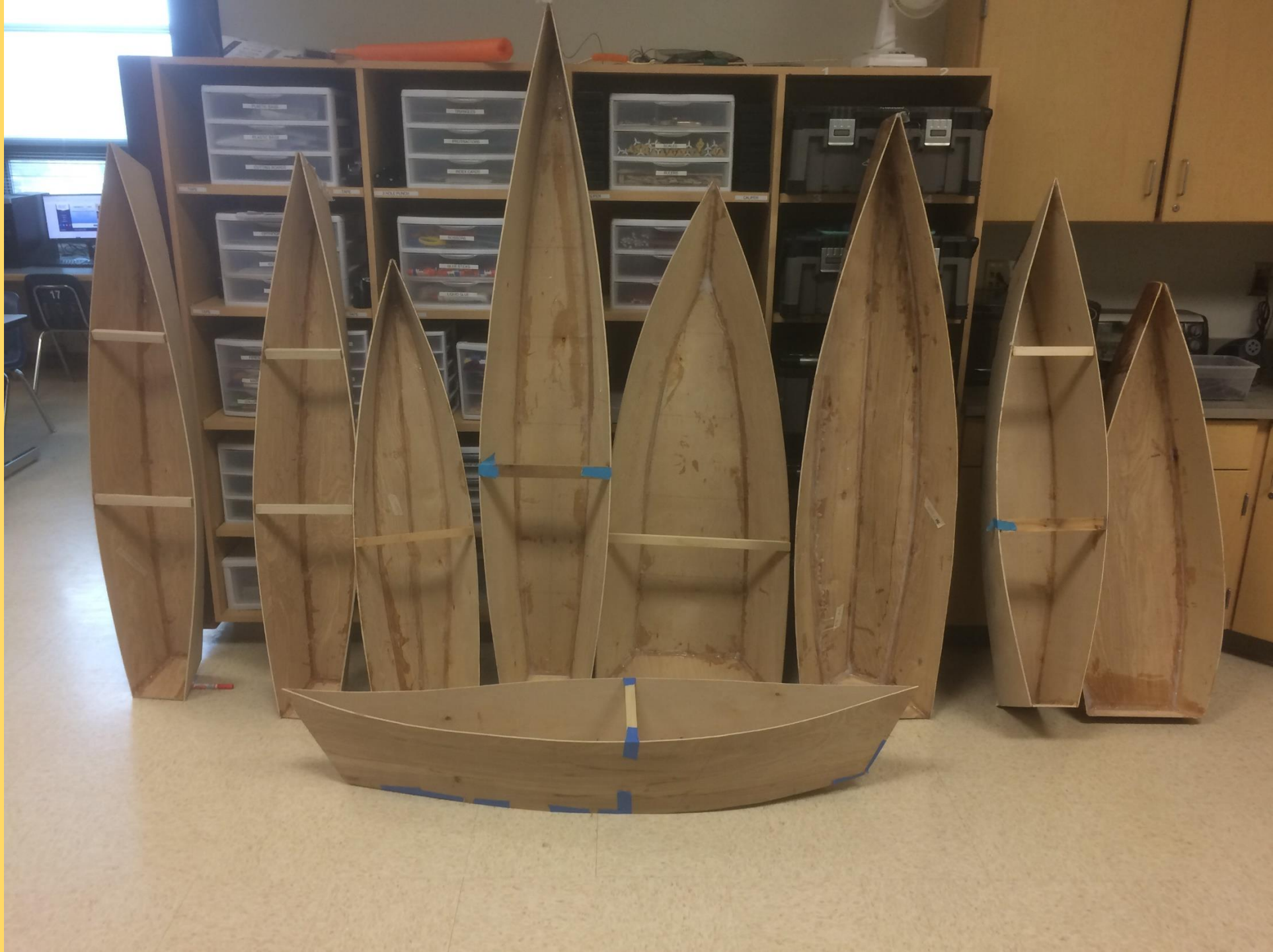
- 50 lb displacement, max length=80 inches
- No requirement for static or directional stability
- Boats designed on developable surfaces
- Rhino trim was checked in a small tank
- Boat too small for an adult passager

Boat Construction

- Boats made from underlayment plywood, 0.2”Thick
- Hulls were assembled stitch and glue
- Outer seams covered with 2 inch tape
- Inside and outside coated with epoxy

Boats in the classroom shop

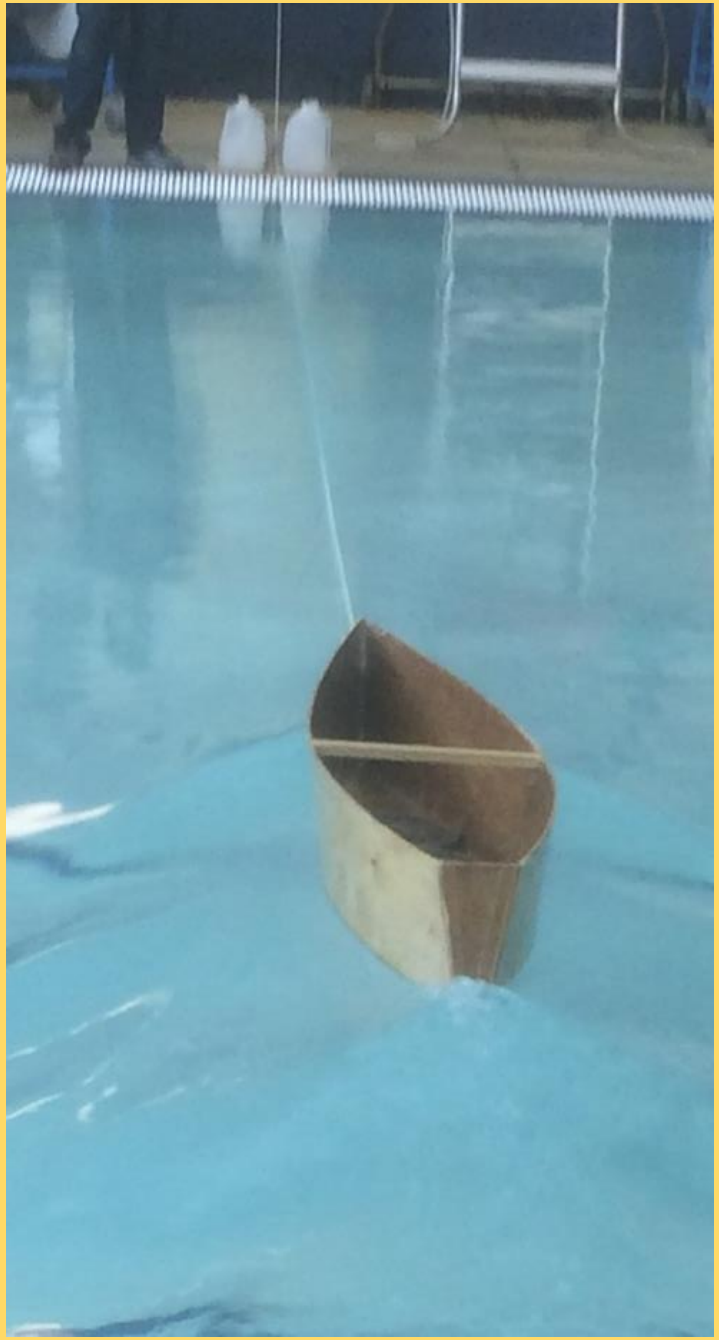
The boats

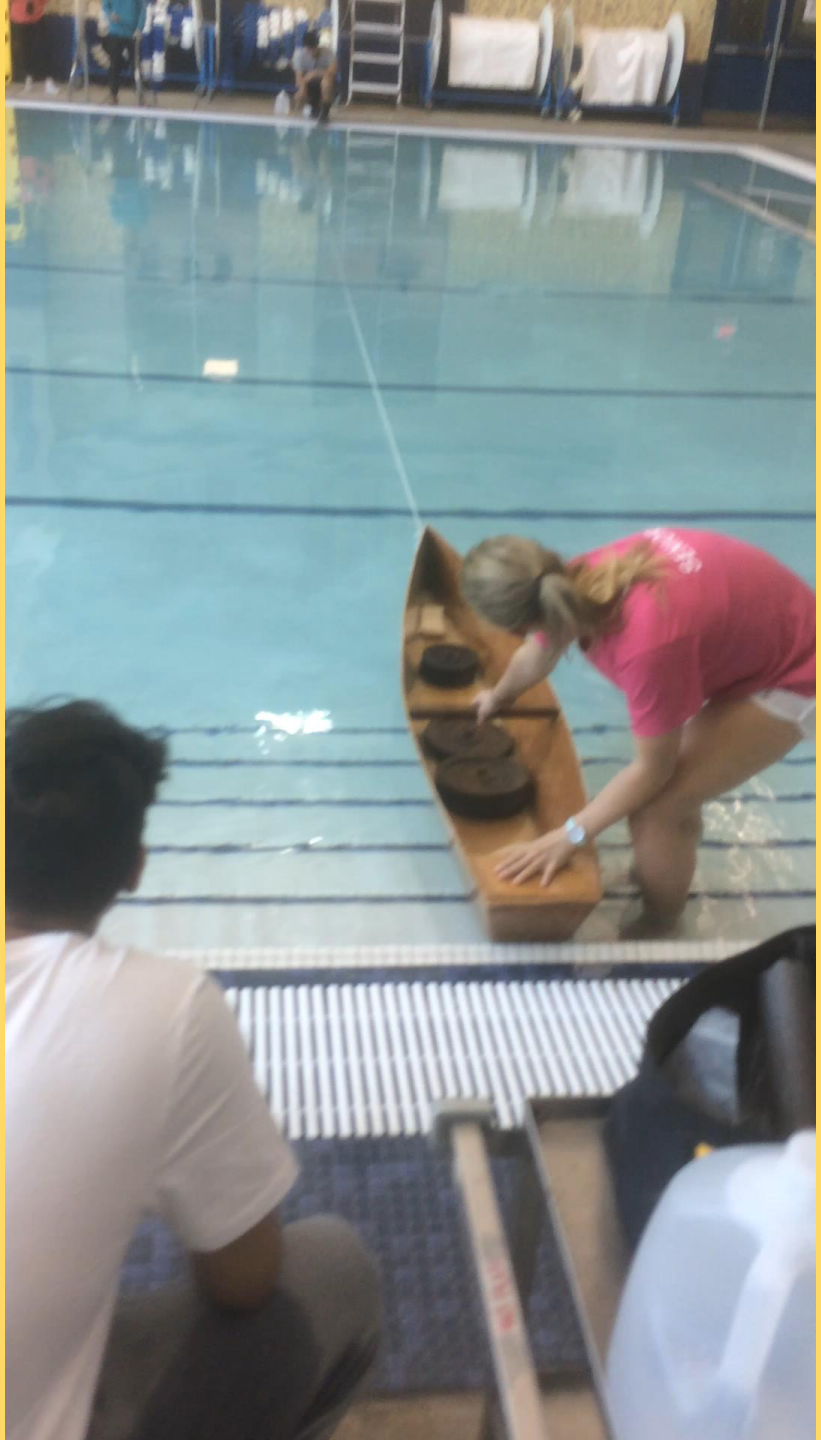


First runs

Testing plan

- Used instructional pool at WL, approx. 50 ft long
- Three timers start watches, and end when boat reaches retrieval point
-
- Yell stop when boat is at the wall
  - This average time, including acceleration and stop transient
- Three stop watches, three runs





Results

WL tests May 2018 class boats in the WL instructional pool

boats released at steps up against the tramsom, release and three timers start timng

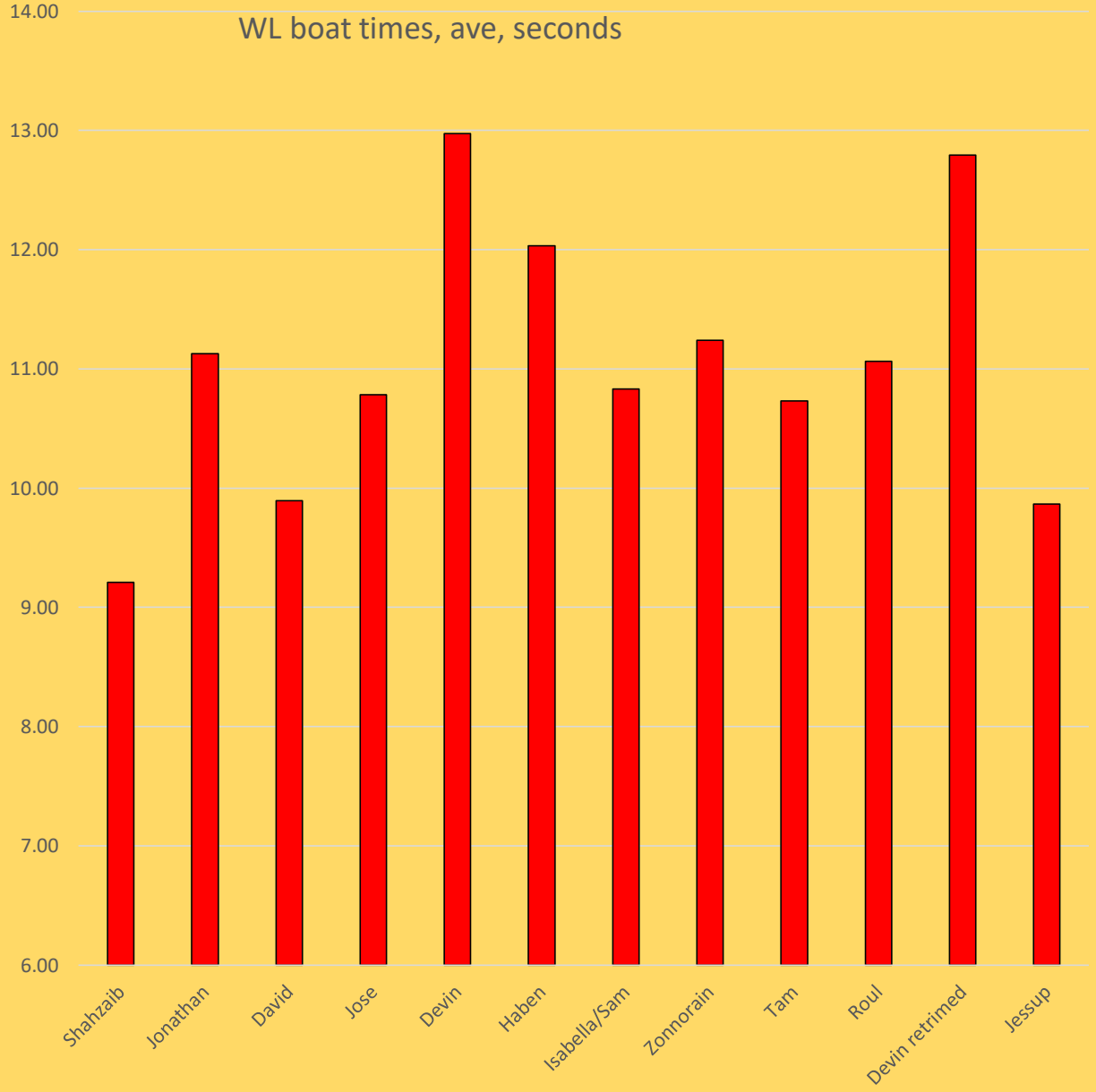
timers stop when boat is stopped at pool edge

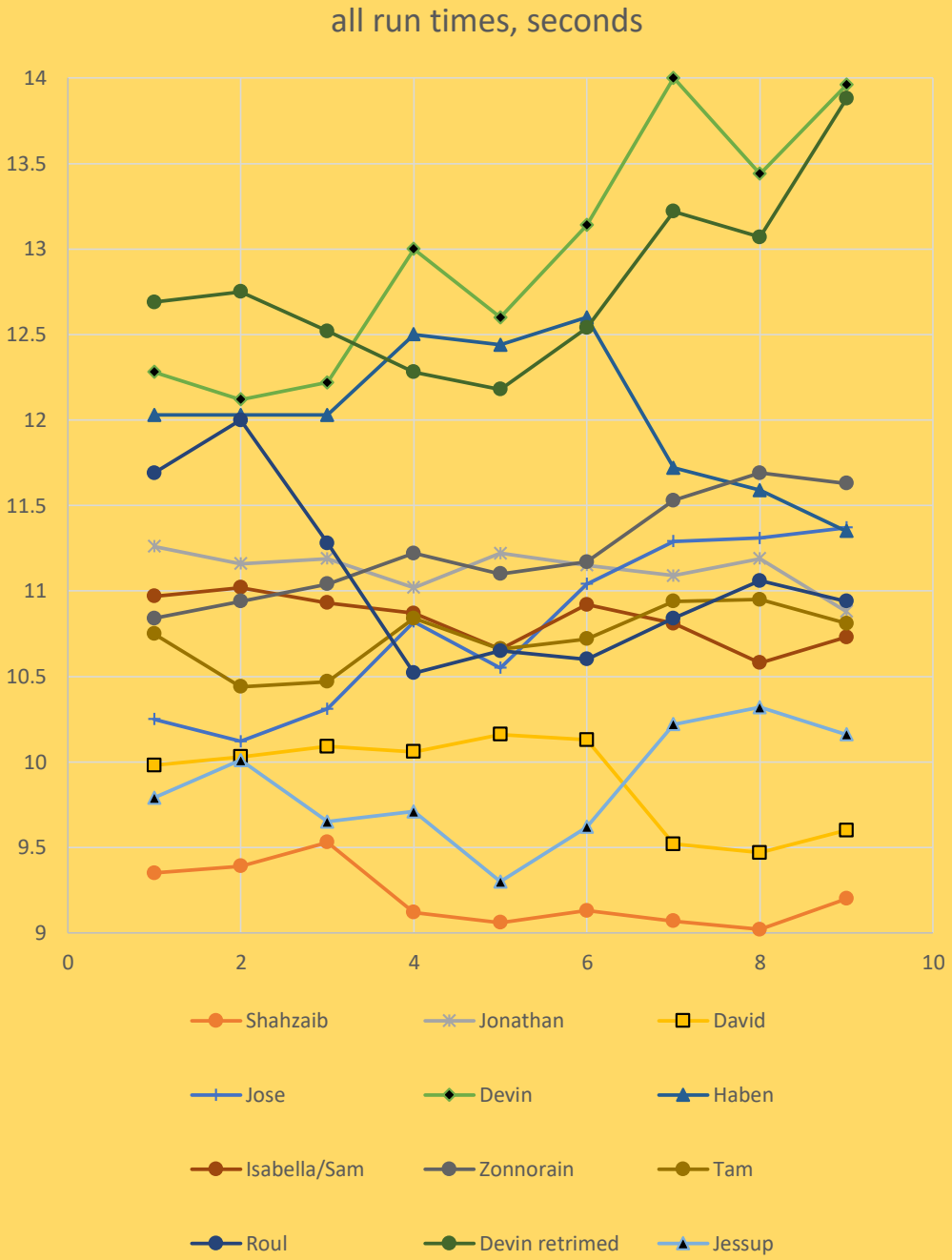
All boats ballasted to 50 lbs, including boat weight

boat builder	run1			run2			run3			ave	date
Shahzaib	9.35	9.39	9.53	9.12	9.06	9.13	9.07	9.02	9.2	9.21	5/10/2018
Jonathan	11.26	11.16	11.19	11.02	11.22	11.15	11.09	11.19	10.88	11.13	5/10/2018
David	9.98	10.03	10.09	10.06	10.16	10.13	9.52	9.47	9.6	9.89	5/10/2018
Jose	10.25	10.12	10.31	10.82	10.55	11.04	11.29	11.31	11.37	10.78	5/14/2018
Devin	12.28	12.12	12.22	13	12.6	13.14	14	13.44	13.96	12.97	5/14/2018
Haben	12.03	12.03	12.03	12.5	12.44	12.6	11.72	11.59	11.35	12.03	5/14/2018
Isabella/Sam	10.97	11.02	10.93	10.87	10.66	10.92	10.81	10.58	10.73	10.83	5/14/2018
Zonnorain	10.84	10.94	11.04	11.22	11.1	11.17	11.53	11.69	11.63	11.24	5/14/2018
Tam	10.75	10.44	10.47	10.84	10.66	10.72	10.94	10.95	10.81	10.73	5/16/2018
Roul	11.69	12	11.28	10.52	10.65	10.6	10.84	11.06	10.94	11.06	5/16/2018
Devin retrimed	12.69	12.75	12.52	12.28	12.18	12.54	13.22	13.07	13.88	12.79	5/16/2018
Jessup	9.79	10.01	9.65	9.71	9.3	9.62	10.22	10.32	10.16	9.86	5/16/2018

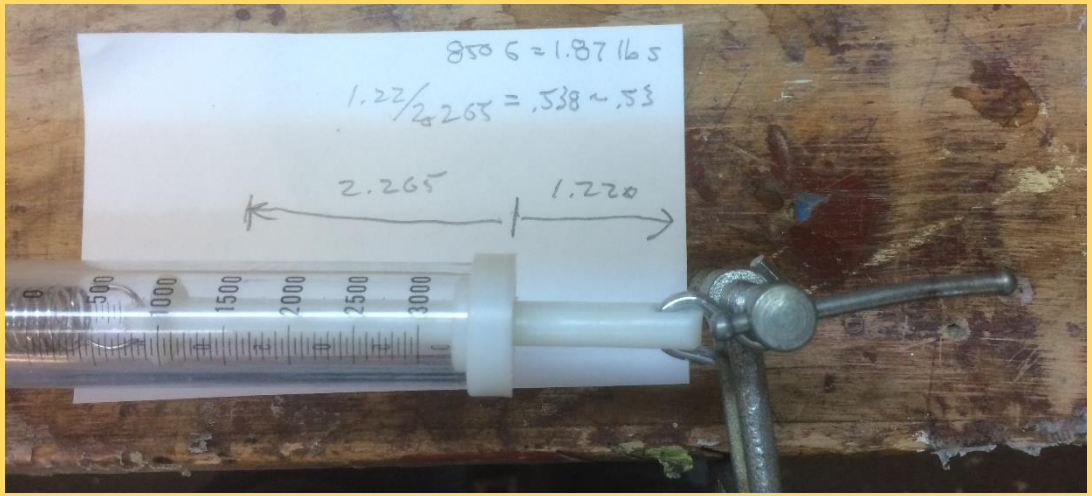
Jose and Devin boats show large increase w/2nd and 3rd run - retest?

Due to rapid turn at run end


WL boat times, ave, seconds
14.00
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
Shahzaib
Jonathan
David
Jose
Devin
Haben
Isabella/Sam
Zonnorain
Tam
Roul
Devin retrimed
Jessup

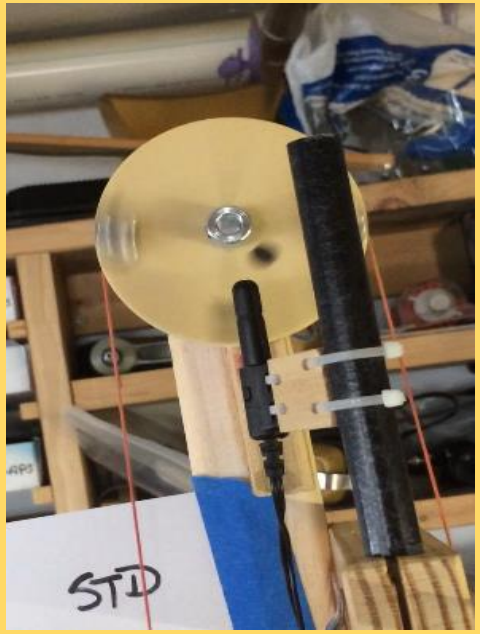

all run times, seconds
14
13.5
13
12.5
12
11.5
11
10.5
10
9.5
9
0
2
4
6
8
10
Shahzaib
Jonathan
David
Jose
Devin
Haben
Isabella/Sam
Zonnorain
Tam
Roul
Devin retrimed
Jessup

Tow force estimate: 1.87 lbs

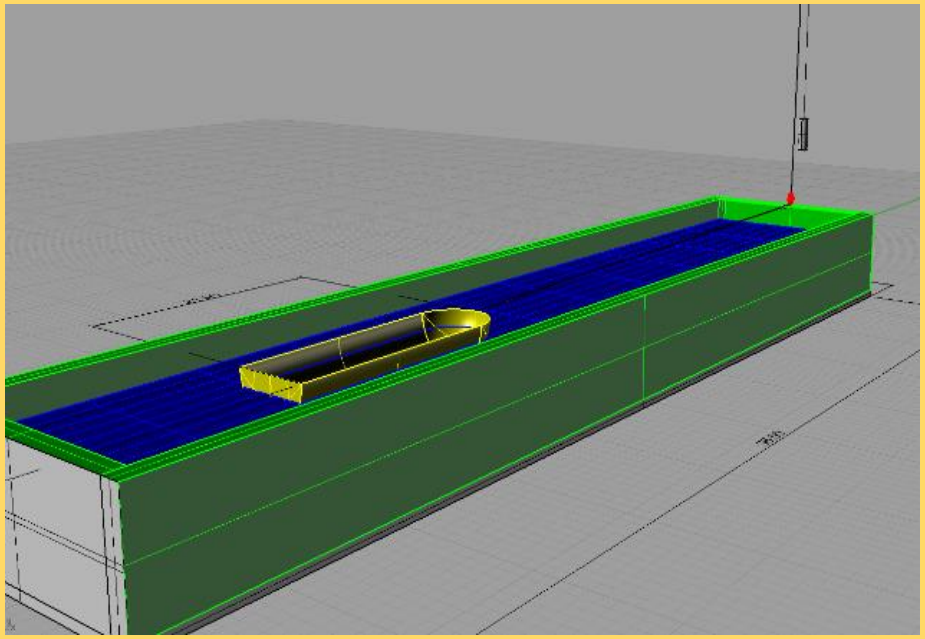


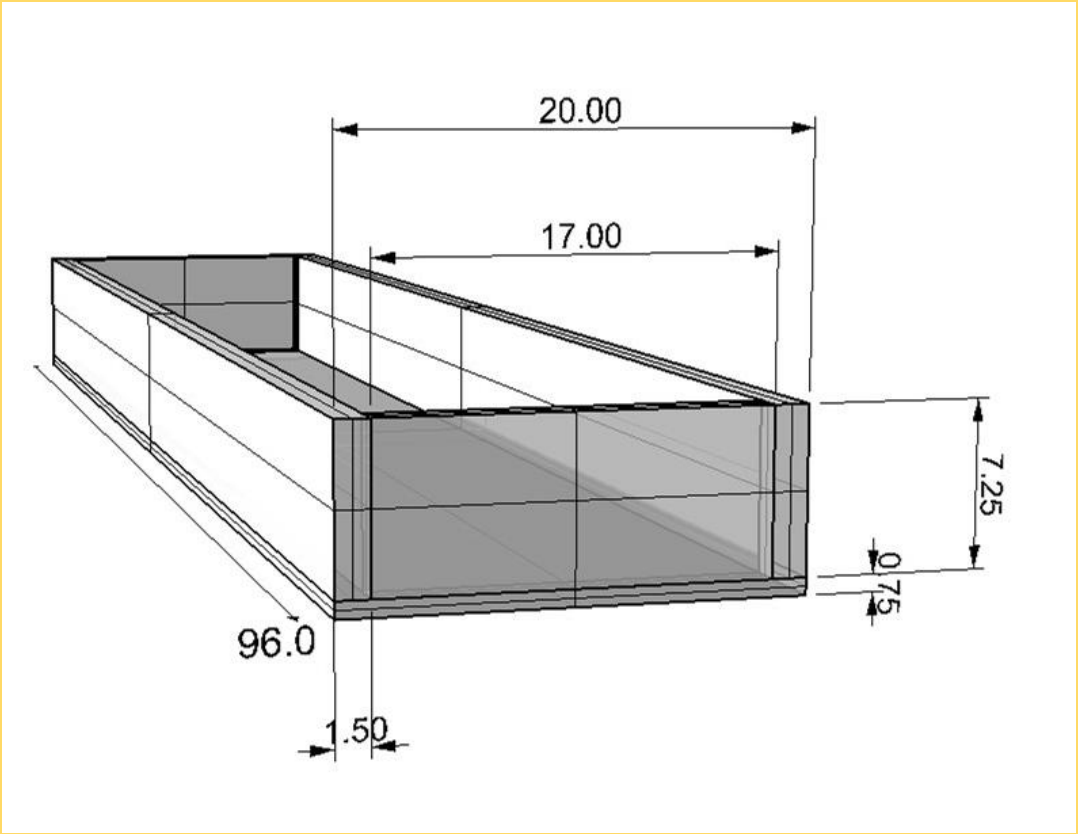
Summary of very small boat building and testing for 4-5 graders

Tank Details



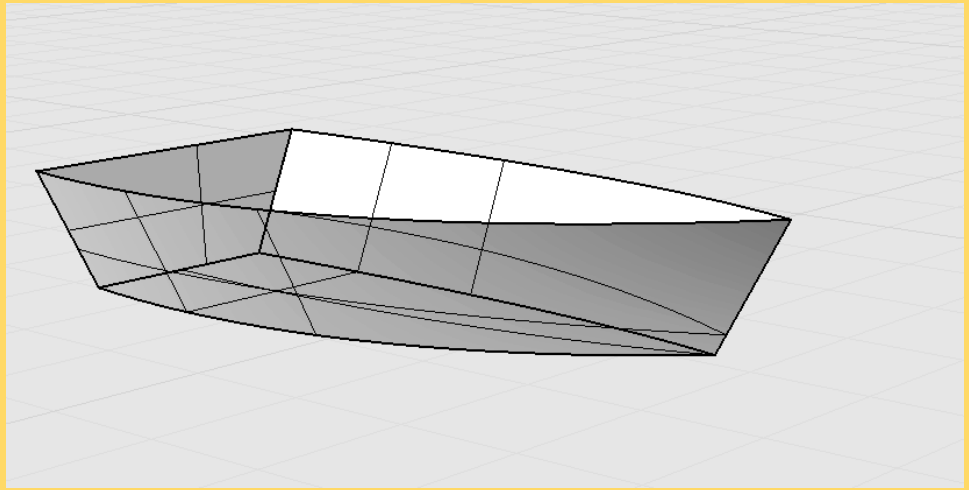
Top pulley and bike speedometer

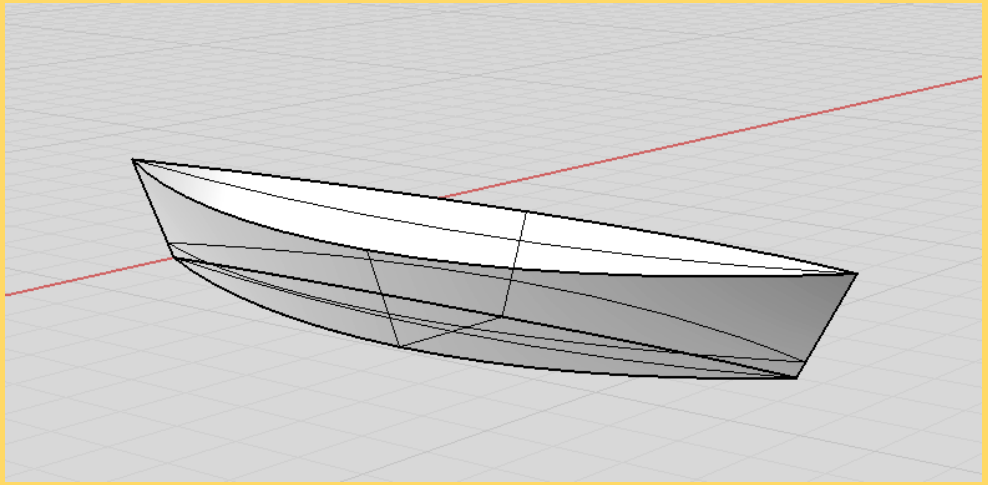




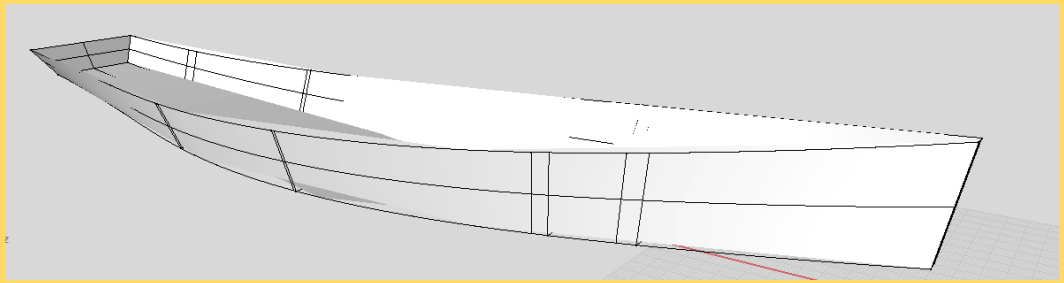
Designs

skiff

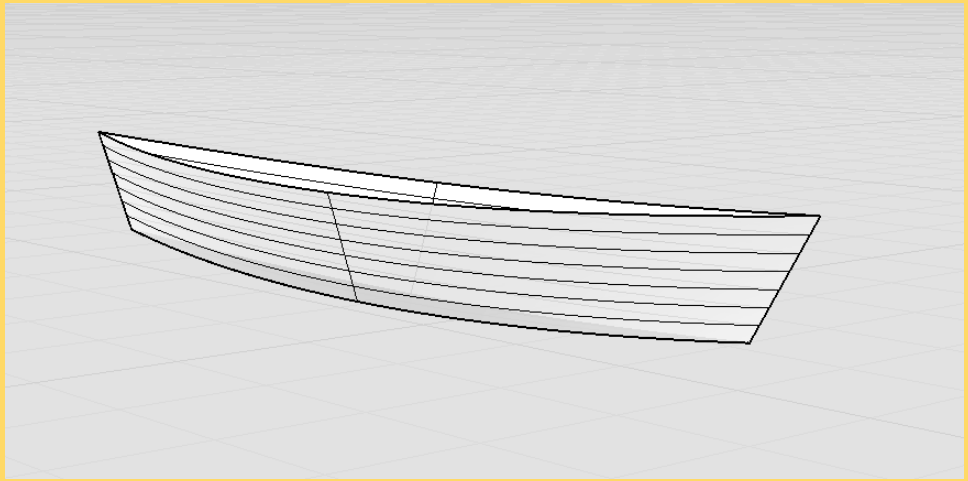




Canoe



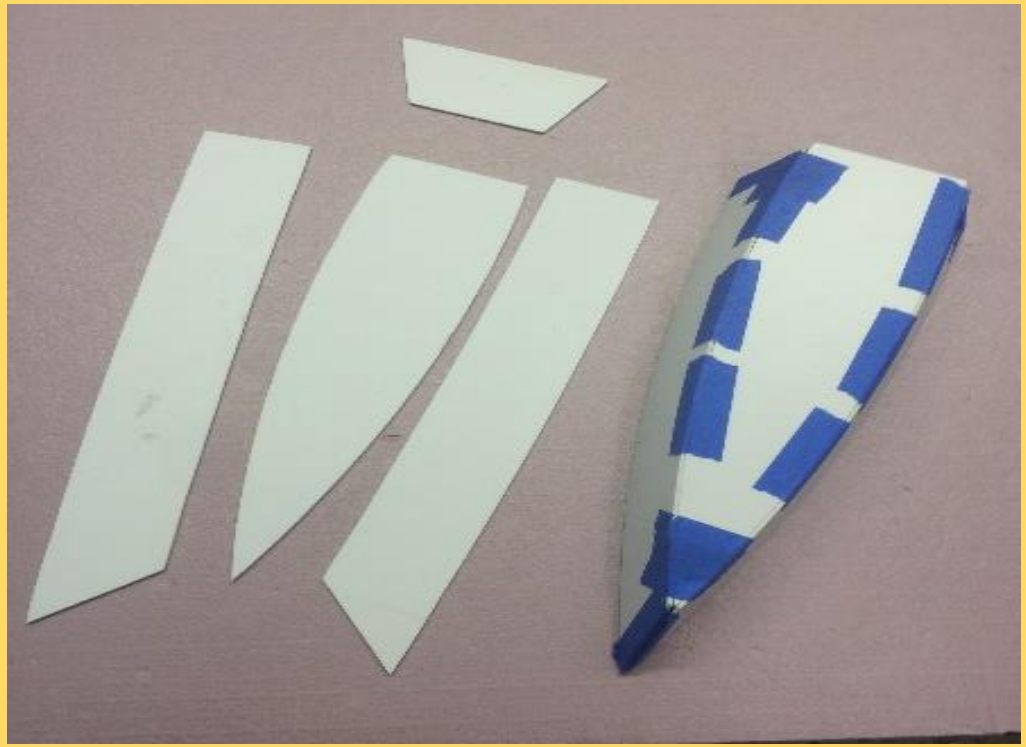
sharpie



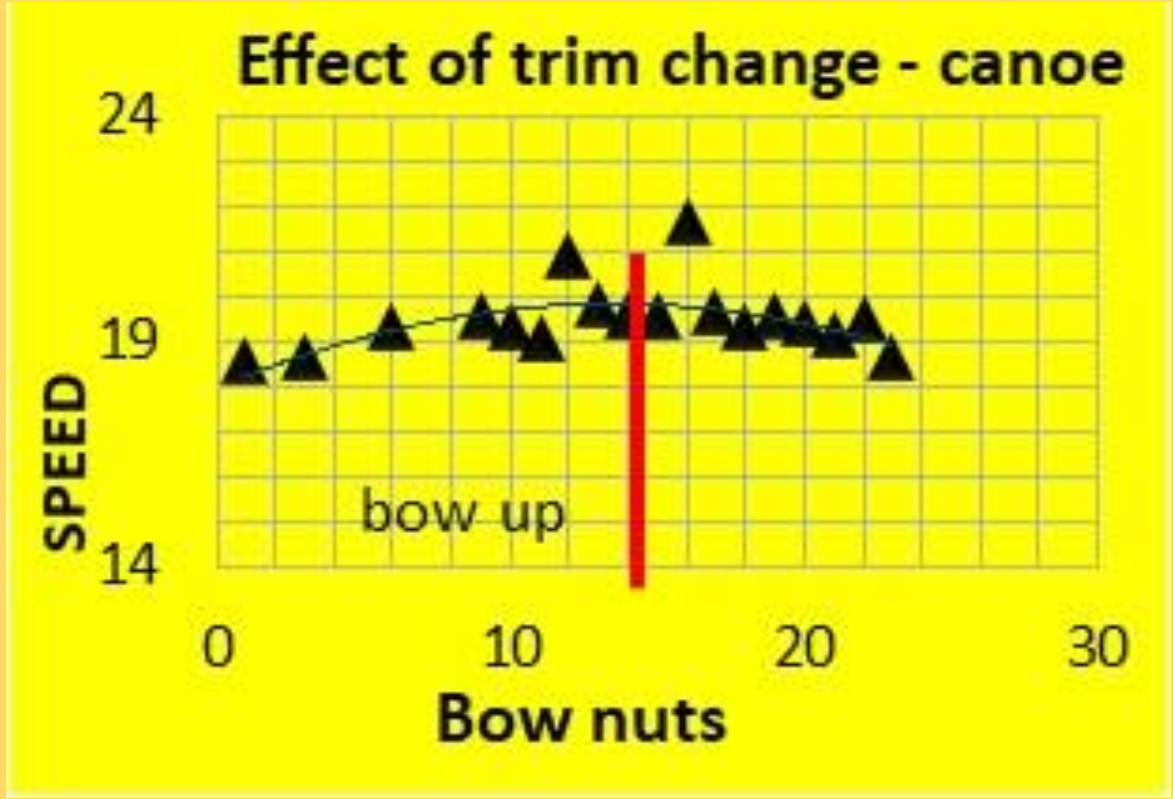
kayak

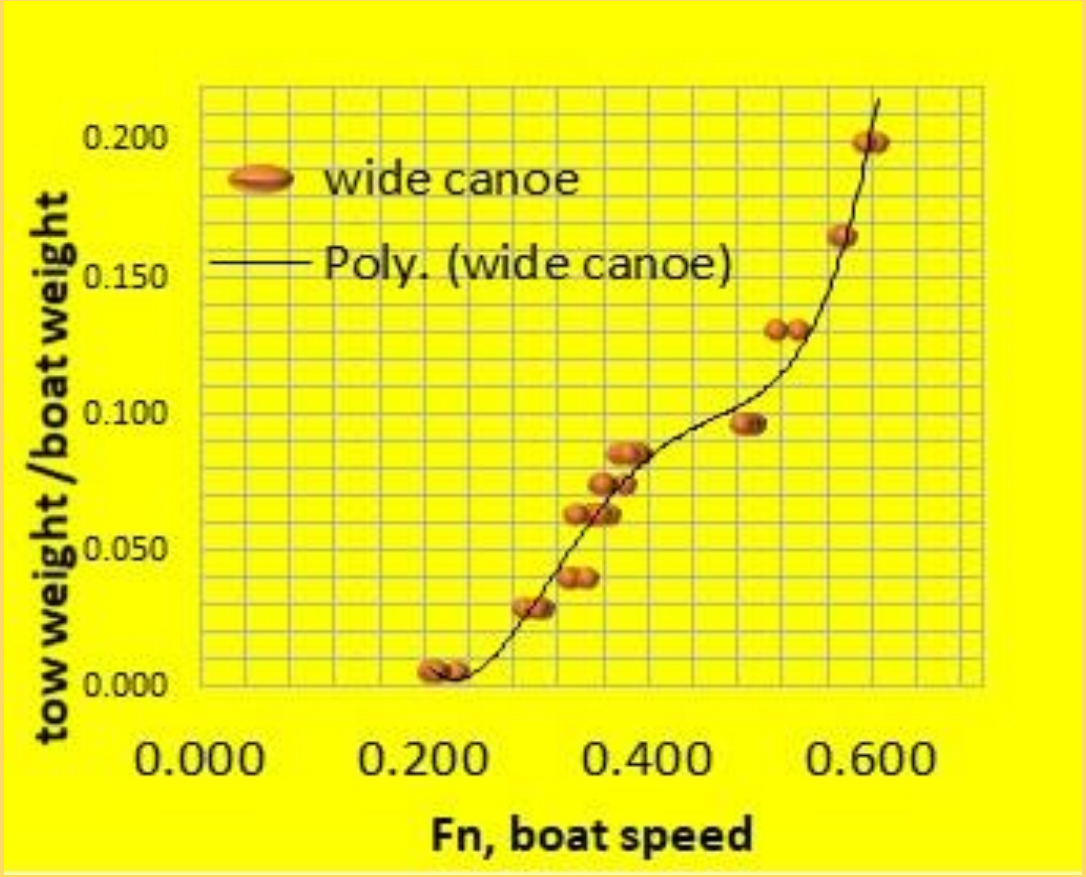
Construction

- Unwrapped developable surfaces cut from 1/16” polystyrene sheet
- Students picked there design, decorated the out side, and taped them together
- Adult volunteers epoxied the inside
- Students removed tape



Some results





18 ¼-20 steel nuts were moved one by one from bow to stern compartments