

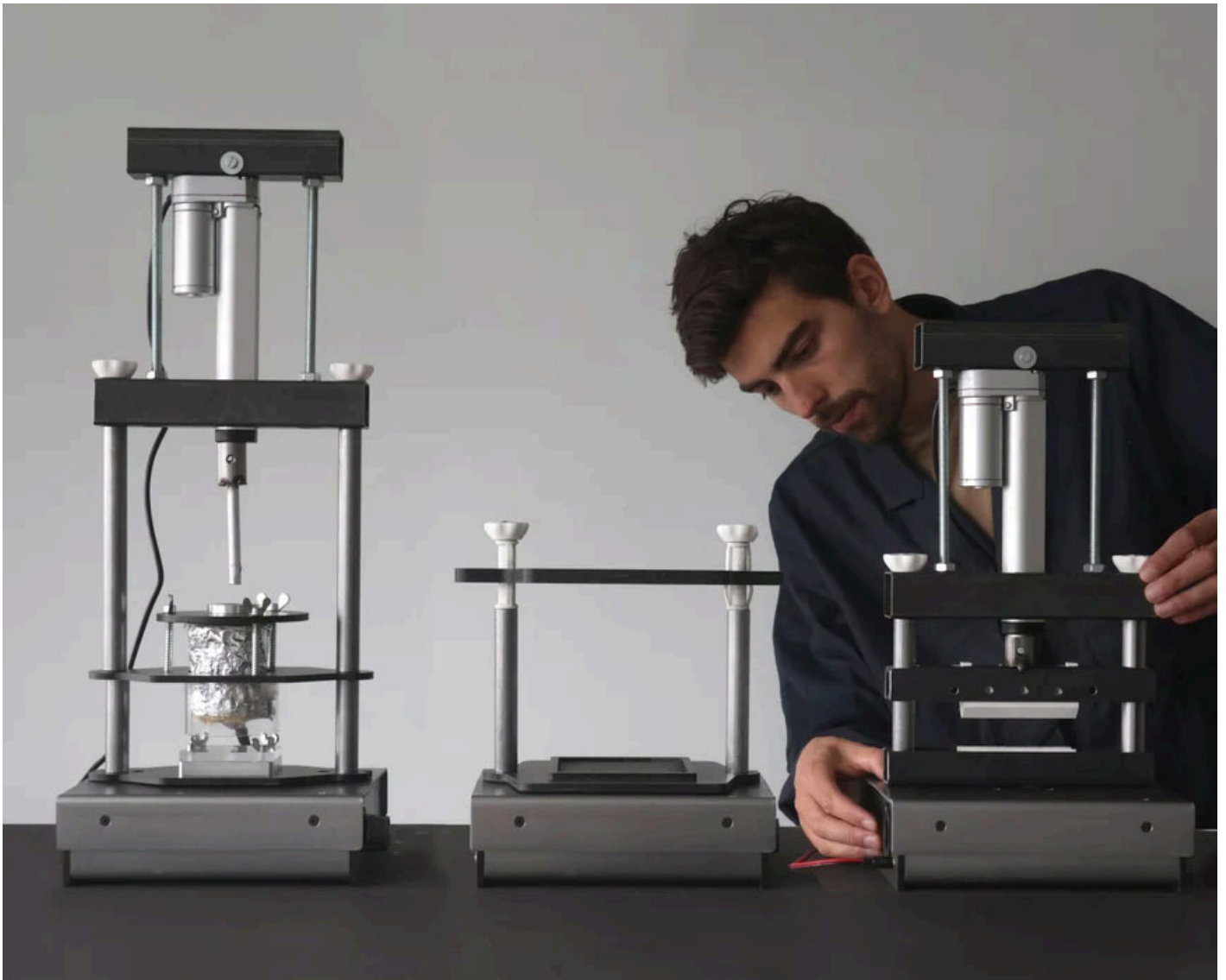
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Experiential Manufacturing Machines for Education

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Introduction: Experiential Manufacturing Machines for Education



[Fusion Projects »](#)

What's the best way to learn about manufacturing? Hands-on, of course!

Unfortunately, manufacturing machines are often expensive, bulky, and potentially dangerous without proper safety training. Especially in an educational context can this limit hand-on learning by experiencing (experiential learning).

Therefore, I developed (as a graduation project) *Experiential Manufacturing Machines*. A versatile educational toolkit that can be configured into small-scale manufacturing machines. Currently, three configurations have been developed, but thanks to its modularity, additional configurations can easily

ly be added in the future. The machines are designed specifically for educational use, but if you'd like to make them yourself, be my guest!

The goal of the setup is to teach students about manufacturing techniques and its materials, as well as its design guidelines, limitations and opportunities. Doing so, by engaging students with an intriguing, exciting and versatile machine. The machines are developed with a focus on producibility and cost-effectiveness.

Disclaimer:

The machines are not CE-certified.

Supplies

The Bill of Materials (BOM) below gives a complete overview of all the parts needed to build the machines. This file is essential for an overview in the following steps. All the parts are divided in different production categories and labelled accordingly.

1. Cutting list
2. 3D printing
3. CNC milling/Lathe
4. Bought parts
5. Lasercut+press brake parts

Step 1: Buy Parts + Cutting List + 3D Printing

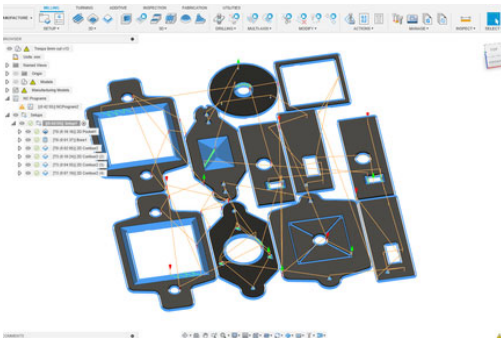
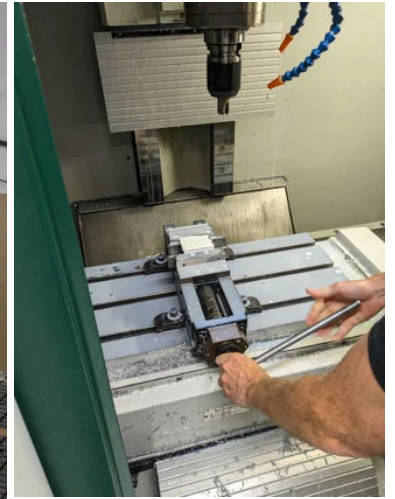


In this step you will choose what configurations you will make, in the BOM you can choose to build all 3 configurations with a base or only one configuration.

1. The machines use a lot of stock parts. Make sure to order all parts from the BOM, with part number '1.xx' and '4.xx'.
2. Cut all the parts with part number 1.xx to size. You can do this with an angle grinder, metal crosscut saw or band saw.
3. 3D Print the 3D printing files required for your configuration. The 3D print files are attached below.

Note; Part 2.1 needs to be printed on its side, in the same way as presented in the picture

Step 2: CNC Milling + Lathe



This step requires a CNC mill and lathe or can be ordered from a local workshop. Order or fabricate all parts labelled '3.xx' as specified in the BOM. The manufacturing files are attached below.

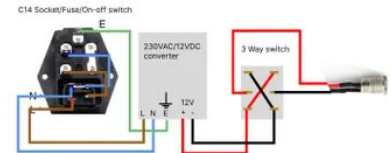
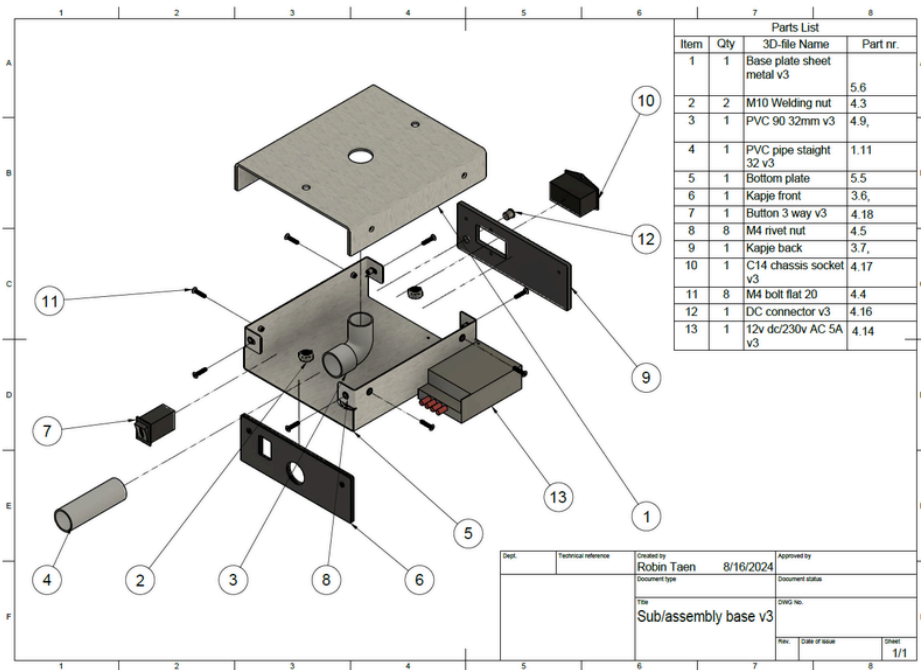
Note; All configurations + base can be milled out of one HPL sheet 570x600x6mm

Step 3: Lasercut + Press Brake



This step requires a metal laser cutter and a press brake, or the parts can be ordered from a local workshop. Order or fabricate all parts labelled '5.xx' as specified in the BOM. The manufacturing files are attached below.

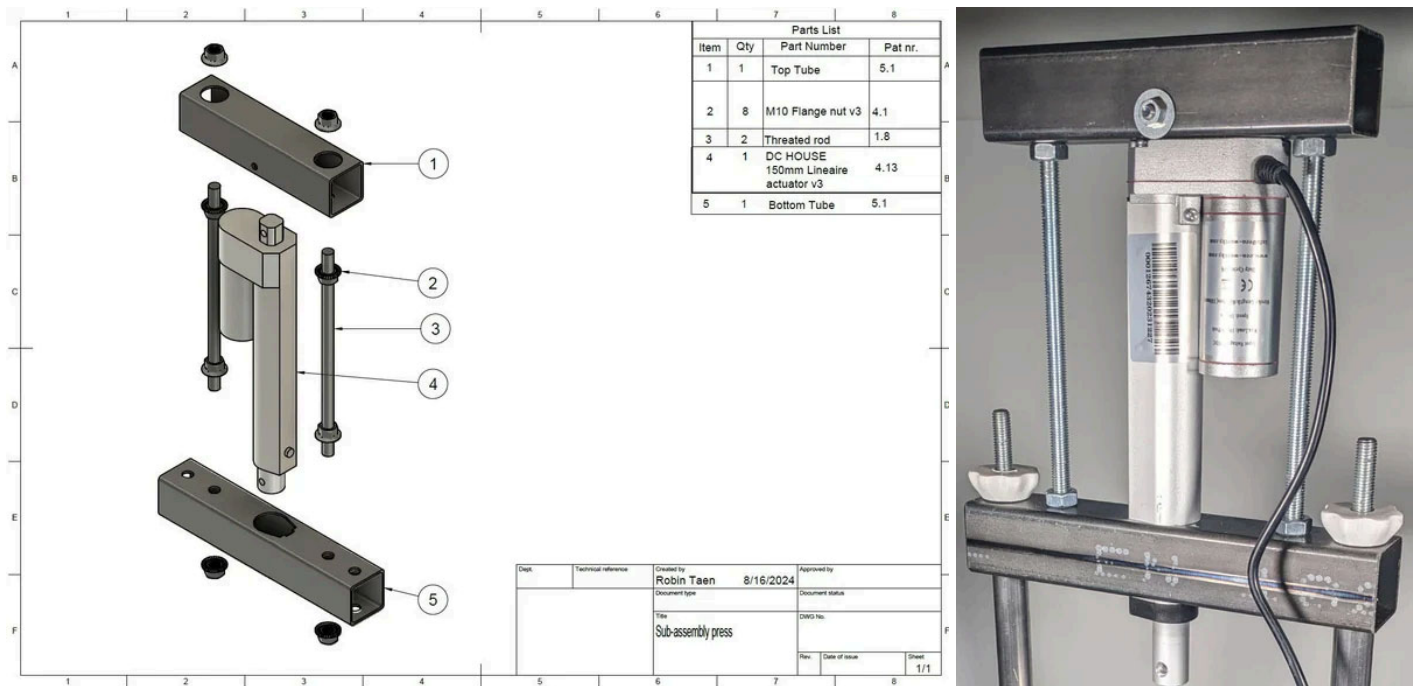
Step 4: Assemble the Base



The base serves multiple functions depending on the configuration. It is rigid and heavy, ensuring stability for all machines. It includes a 230V AC to 12V DC converter to power the linear actuator for the injection and press brake configurations. The base is constructed from bent steel sheets with H PL sides, and the PVC pipe in the center is used for vacuum forming. Assemble the base in the following order.

1. Rivet all rivit nuts (11) on the Bottom plate (5).
2. Bolt the AC/DC converter (13) to the Bottom plate (5).
3. Spotweld the Cap Nuts (2) on the Base plate (1).
4. Glue (with pvc glue) the two pvc parts together. (4) + (3).
5. Press fit the pvc pipe (4) trough 'kapje front' (6).
6. Click the 3 way switch (7) in 'kapje front'(6).
7. Bolt C14 chassis socket (10) onto 'kapje back' (9).
8. Screw the DC connector onto 'kapje back' (9).
9. Connect the wiring (part nr. 4.11), following the wiring diagram from the image above.
10. Bolt the top (1) and bottom (5) in place with the m4 bolts (11).

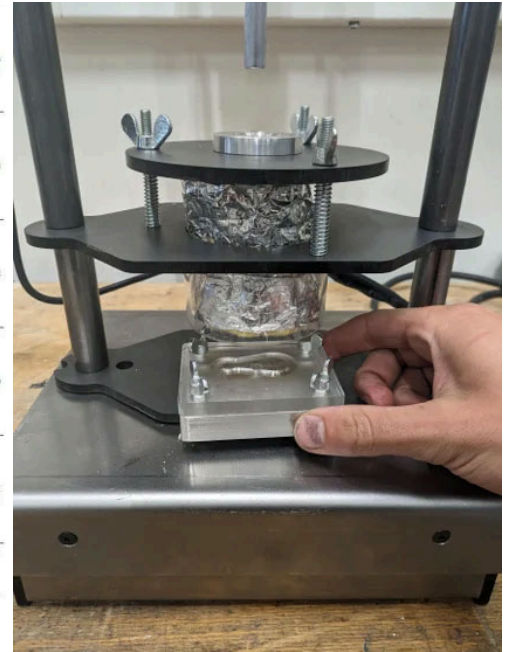
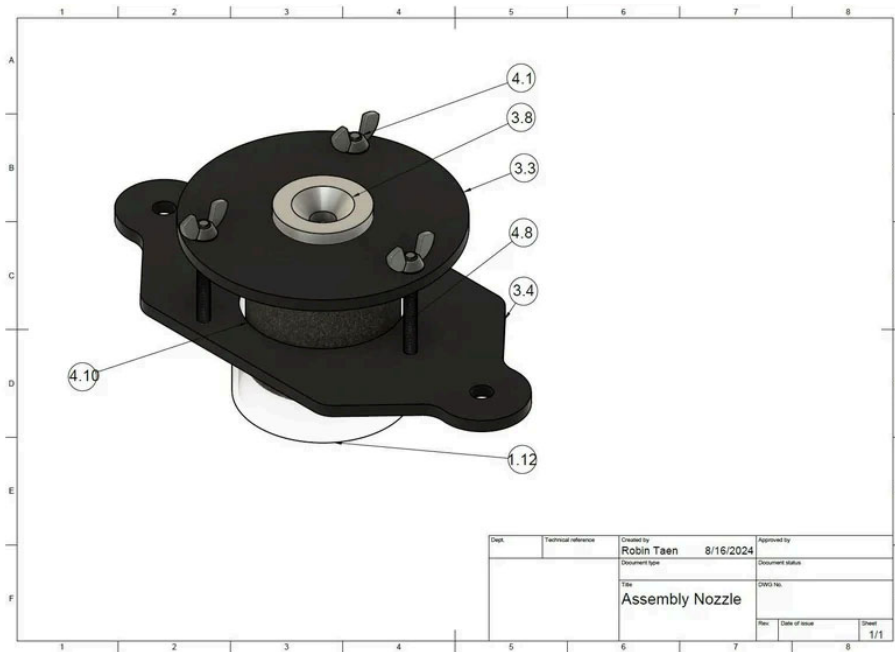
Step 5: Assemble the Press



Assemble the press in the following order.

1. Connect 2 nuts (2) on each threaded rod (3)
2. Slide the top tube (1) and bottom tube (5) over the linear actuator (4) and the two treated rods (3)
3. Bolt the assembly together with the 4 leftover nuts (2)
4. Connect the linear actuator (4) to the Top tube (1) with a bolt (not in assembly, chose something that fits).
5. Connect the male DC connector (part nr. 4.16) to the linear actuator (4)

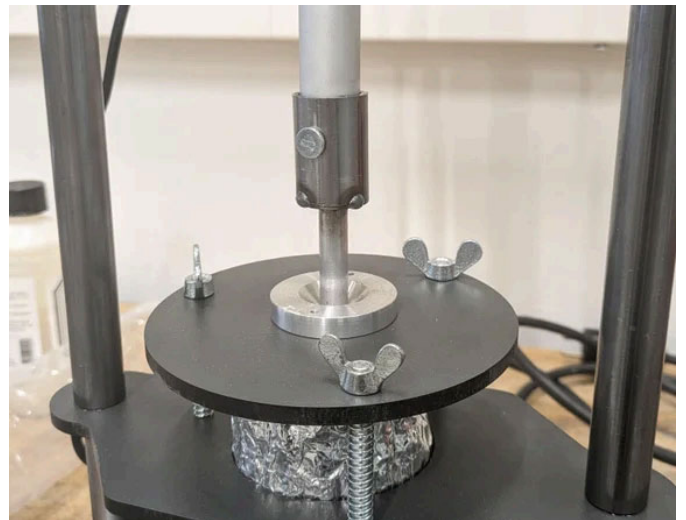
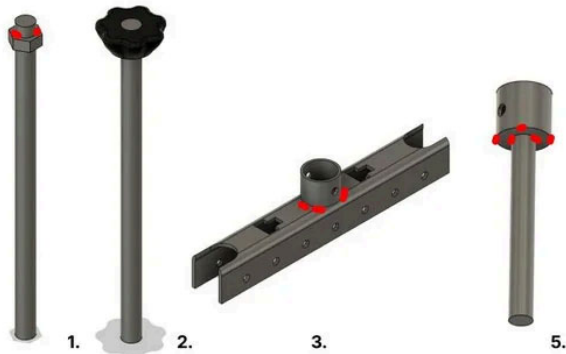
Step 6: Assemble the Nozzle



Assemble the nozzle in the following order

1. press the PTC element (4.15) into the nozzle sloth (3.8)
2. press the aluminium nozzle (3.8) into the nozzle holder top (3.3)
3. Warp the aluminium nozzle (3.8) in the Rockwool (4.10)
4. Glue the acrylic tube (1.12) in place with the nozzle holder bottom (3.4)
5. Bolt the assembly together with the M6 bolts (4.8), springs (4.19) and the wingnuts (4.1)

Step 7: A Few Bits of Welding

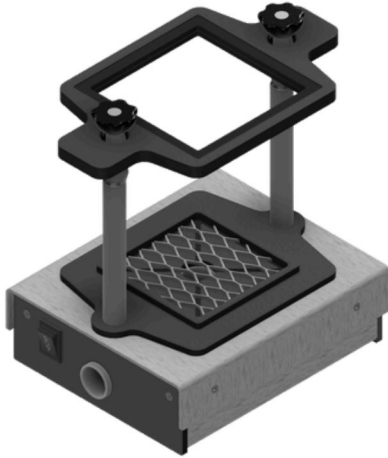


1. Spotweld M10 nut (4.2) to M10 threaded rod (1.5, 1.6, 1.7) 2x on a distance of 1 cm from the edge
2. Glue 3D printed M10 Nut ring v2 (2.3) all the threaded rods from above
3. Spotweld piston v3/top part (1.4) to the centre of 'Gelijder v3' (5.3)
4. Spotweld piston v3 (1.9) to piston v3/top part (1.4). Use a washer to fill in the gap.

Step 8: Ready to Start Building!

In this stage all parts are assembled and you can start to build the machines!

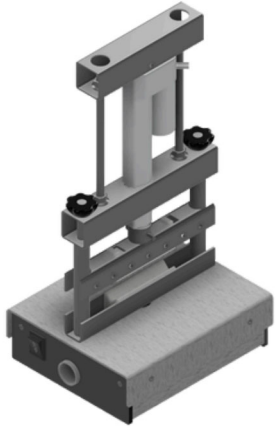
Step 9: Vacuum Forming Configuration



The picture above should provide sufficient instructions to build the machine. If you encounter any issues, you can refer to the attached assembly file for further guidance.

The vacuum forming machine allows plastic sheets up to 150x150 mm with a thickness of up to 2 mm to be vacuum-formed. I have good experience with PETG and Vikureen sheets (PC). To let students experience how the plastic behaves, heating is done manually with a heat gun, and suction is created by an external vacuum cleaner. By heating manually errors (and learning opportunities) are increased.

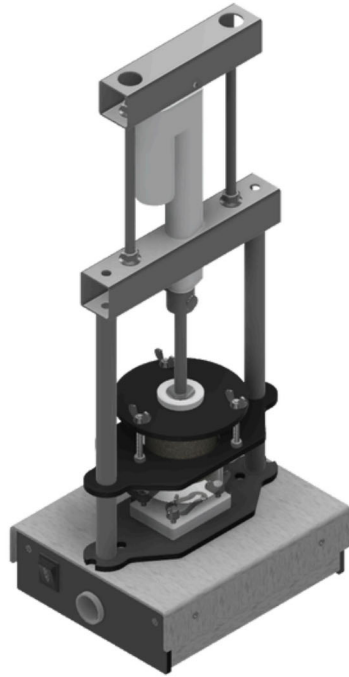
Step 10: Press Brake Configuration (Metal Bending)



The picture above should provide sufficient instructions to build the machine. If you encounter any issues, you can refer to the attached assembly file for further guidance.

The press brake can bend metal up to 100 mm long and 2 mm thick. Different 3D-printed molds can be used to achieve the desired angle. What distinguishes this machine from much simpler metal bending tools is its educational focus. The machine is designed to reflect real-life limitations that occur with industrial machines, such as potential collisions with the machine or die and the requirement for a minimum leg length. Currently, the press uses a linear actuator capable of applying up to 1000 N of force. If more force is needed, the actuator can be upgraded, but this may also increase the risk of potential hazards.

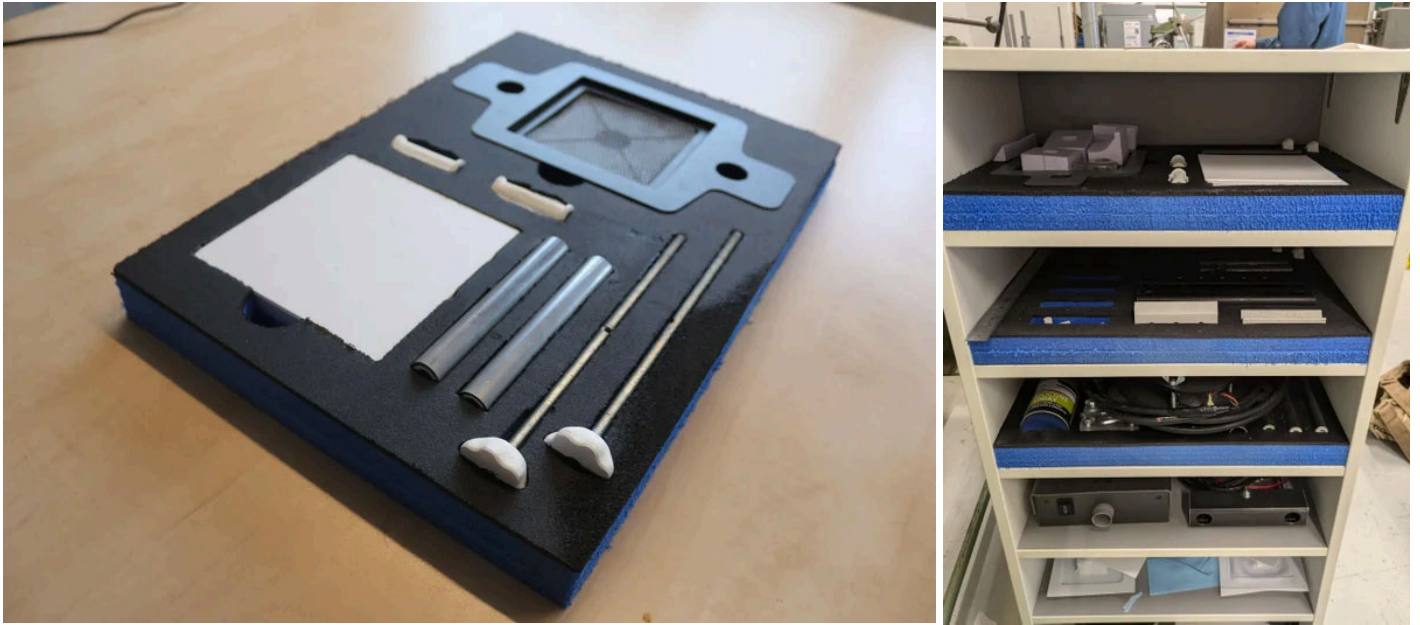
Step 11: Injection Molding Configuration



The picture above should provide sufficient instructions to build the machine. If you encounter any issues, you can refer to the attached assembly file for further guidance.

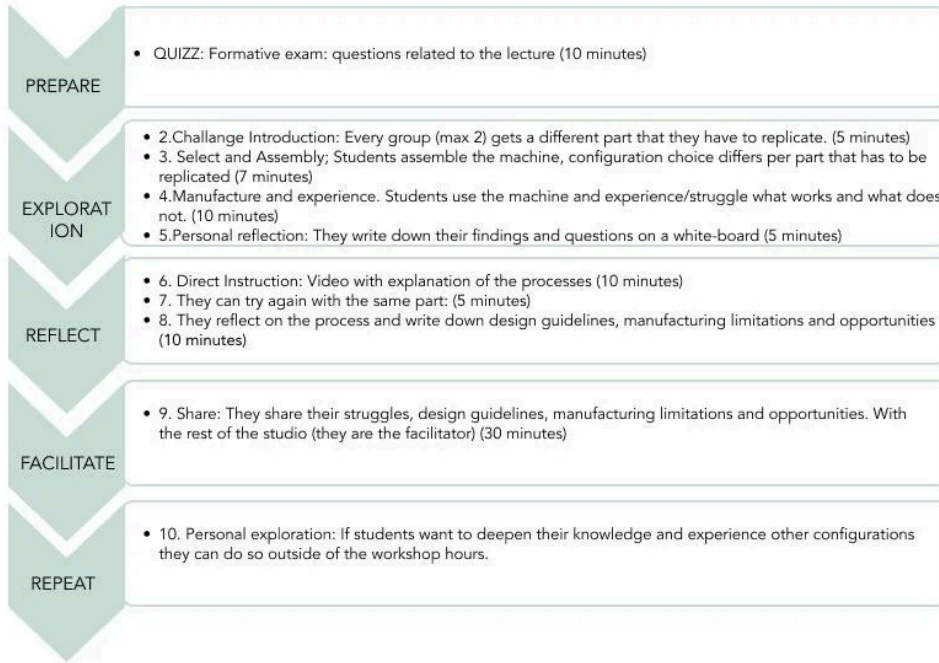
The injection molding configuration is designed to inject plastic into a mold with a volume of up to 10 cubic centimeters. What makes this setup unique is its simple yet effective heating method. By utilizing a powerful yet affordable PTC element, similar to those found in heat guns, the nozzle can reach the temperature required to melt small volumes of PLA. The mold features an acrylic top, allowing students to observe the molding process.

Step 12: Storage and Presentation



With all these different components, it is important to create an overview. By separating the different configurations into different inlays, a clear overview is created, showing only the parts needed for that particular machine. This technique is often used in workshops and immediately draws your attention if something is missing. At my university, they happened to have these trolleys available, but there are various ways to store and present the machines.

Step 13: Educate



The Experiential Manufacturing Machine can function as a standalone tool or as part of a workshop. In this case, the machine is integrated into a workshop using a productive failure (PF) approach. This approach flips the traditional learning process by beginning with an exploratory problem that students cannot solve, followed by instructions that fills in the missing concepts. This method actively engages students in problem-solving.

The workshop setup, as illustrated in the image above or the attached PDF, utilizes several machines in a classroom with 20 students.

Step 14: Share



I hope this Instructable has inspired you and provided enough information to develop the machines yourself, either as educational resources or as hobby projects. If you have build a machine yourself, want to buy one or if you have any other questions, feel free to reach out to me at; [REDACTED]