Key Flaws in Designing Prototype During 2019-2020 School Year

During the 2019-2020 school year, several issues were faced in designing the prototype for this specific function. Unfortunately, these issues are not the main reasons for the failure to produce a working prototype. Instead of incrementally and systematically solving issues with a single design, the prototype was constantly being thrown out and completely redesigned as a result of almost every issue faced. This was due to teacher and peer decisions to explore solutions to problems that alienated other aspects of the design. By the end of the year, the design being pursued was not even true to the original ideal with little to no reason for this shift. Because of this there is no clear prototype to critique. That said, the most common, most difficult to solve, and most recurring issues of the prototypes made during the 2019-2020 school year are:

1. **Indecision & Constant Major Design Changes Stifling Development**

Due to constant scrapping and restarting of the design, little was decided on for design. Each design was being remade in an attempt to fix every issue and unknown with the prototype. As a result of this, the project was left in a state of stasis, where designing parts still were determined by the end design of others. Rather than a natural evolution of the design or following the engineering and design process, each prototype was authoritatively quashed and effectively thrown out. This resulted in many key components not being designed by the end of the school year:

* Piston Head
* Access Hatch
* Washing Machine Frame
* Wash Chamber Top
* Automatable Piping System

Trying to design the prototype in this way prolonged the designing of key components to the point where they could not be completed, and served as the catalyst for a majority of the problems faced with designing the prototype by the end of the year.

1. **Issues With the Wash Chamber**

While designing the wash chamber, finding a way to create the wash chamber so that it could hold a seal with the piston head and accommodate the pipes and the access hatch presented itself as a problem. After several iterations of the design, it was decided that the wash chamber would be built out of multiple 4” Schedule 40 Tee Fittings, with reducers to connect to the pipe and two open ends for the shaft of the piston to exit out of one direction, and the access hatch on the opposite side. This solution would not have worked, bringing on a host of other issues:

* **Wash chamber too large for water requirements**

The main function of the washing machine, being moving fluids between parts of the washing machine to carry out the wash process, the design can only work if the wash chamber is the correct size to hold only clothing items and the specified 500 mL of water.

* **Non-Uniform Wash Chamber Walls**

Making a seal between the piston head and the walls of the wash chamber requires a uniform surface along the travel path of the piston head wherever it goes and along all parts of the seals. Having fittings with irregularly shaped walls which are connected by glued PVC pipe in between means that the piston cannot hold a seal.

* **Too Much “Void Space” in the Design**

Another issue with having a large wash chamber with an irregular shape is the overabundance of “void space”. In the context of the washing machine, “void space” is an open volume in the wash chamber that fluids can flow into. Where the issue starts is that this space is not used, and cannot be manipulated by the piston head, and trying to make the machine work with more void space only means it will require more fluid to function. “Void spaces” cannot be eliminated when dealing with fixed volumes of fluid, as even pipes can be void spaces. Because of this, “void spaces” need to be minimized.

1. **Not Being Able to Address Multiple Constraints**

This is an issue that will continue to be faced as a prototype is developed due to budget and material availability. For the washing machine prototype designed during the year, it was way too large and could not be automated due to the inability for the team to locate electronically controlled valves at a cost that fit within the budget. Concessions of all types were made for budget and availability, such as using 4” Schedule 40 Foam Core PVC Pipe over 4” Schedule 40 Clear PVC Pipe, which is more robust and uniform in shape for sealing, and also is transparent as per the additional criteria of the project.

1. **Additional Unaddressed Issues**

* **Non-adjustable wash chamber size**

This is an important component for not only handling varied sizes of clothing, but also is important for regulating pressure in the system as the pressure of the fluids increase and decrease during the wash process (not caused by piston acting on clothing, but rather piston arm entering and exiting the closed system, increasing and decreasing the chamber size).

* **No Internal Measurements or Sensing**

While the washing machine is in operation, it is important to know the pressure of the fluids in the system, and the force being applied by the linear actuator, or the location of the piston head in the wash chamber among other things. Without this feature, it is nearly impossible to automate the system, and operating it comes with increased risk of damage to the system itself. Additionally, Important information that could improve the design is harder to acquire, with separate testing apparatuses being required to learn new information about the design.