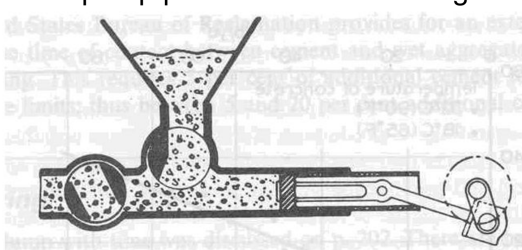
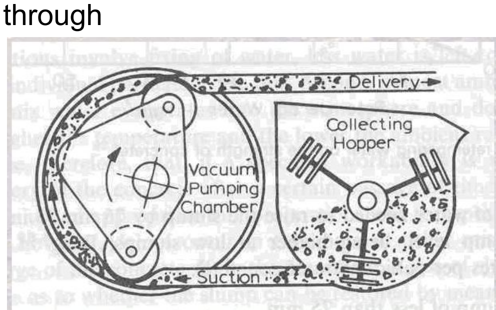
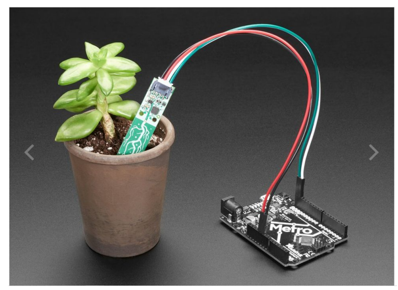
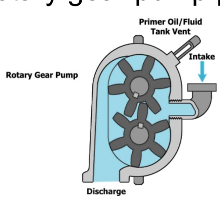
Concept Generation:

#	Concrete Extrusion	Keeping Concrete at right moisture level
1	Gravity pulls concrete through, valve controls flow	Put concrete into a sealed reservoir
2	Syringe is filled with concrete then compressed	Constantly mix concrete and add water at defined rate
3	Motorized auger pushes concrete through tube	Extrude a dry powder than spray with water, eliminating the need for moisture level maintenance
4	Concrete is manually pushed through by hand	Have students check concrete at a time interval and add water by hand if needed
5	Piston pump pushes concrete through  (a) Direct acting piston pump https://en.wikipedia.org/wiki/High-density_solids_pump#Types_of_piston_pumps	Put a wet “curing blanket” over that top of the concrete in the reservoir to prevent it from curing too quickly 
6	Concrete and water are mixed at the nozzle reducing pumping needs	Mix concrete at the nozzle so curing before extrusion isn’t a concern
7	Peristaltic pump (squeeze pump) pushes concrete through  (b) Squeeze pump	Chill the concrete reservoir to slow the rate of evaporation, heat the nozzle to reducing curing time once extruded

8	Extrude a dry powder, then spray the power with water https://newatlas.com/berkeley-researchers-pioneer-powder-based-concrete-3d-printing/36515/	Use a mucus membrane like a snail to prevent water from evaporating from the concrete 
9	Use cold water when mixing concrete to slow the curing process, heat the nozzle to hasten the curing time after extrusion	Use a programmed moisture monitor to alert the students if more water needs to be added to the concrete mixture 
10	Rotary gear pump pushes concrete through 	Print all the concrete quickly enough where there isn't time a significant amount of moisture to evaporate

Selection Criteria:

Simplicity - We want to reduce the number of parts (especially moving parts), amount of assembly, level of calibration, and software controls needed. The more simplistic the design the less likely it is to fail and when it does fail, the easier it is to fix.

Cost - With only a $500 budget we will need to spend our money wisely in order to not quickly exhaust our resources. Some of my ideas for concrete extrusion would probably cost >$500 for the pump alone, so we need to consider this constraint.

Ease of Use - Because the printer will likely be used by many different groups, with many of them not receiving any formal training on the printer, ease of use is very important. Now sometimes there is overlap between simplicity and ease of use, but not always. For my moisture level maintenance ideas, having a moisture sensor makes it easier for the user but the system is more complicated than having the students check the moisture manually at time intervals.

Size/Weight - Because we have a size requirement we need to hit, we will have to make sure any part of our design doesn't put us at risk for not satisfying that requirement. Weight is also a concern, as teams will have to move the printer. Weight is also a huge concern on the extruder specifically, the heavier the extruder the slower it can safely move. This also impacts stepper motor selection and axis design.

Safety - Every part of the design must be safe to use for all students. We need to consider failure modes and potential safety issues.

Repeatability - Everything we select for the printer should be easy to acquire and/or replicate. This is critical for the repairability of the printer. We should keep custom parts to a minimum and make sure our sourced parts are widely available. This repeatability would also make it possible for a second (or more) printer to be constructed.