3D Printed Heat Exchanger for Use in Pediatric Surgeries

Overview
Heater-cooler devices (HCDs) are used during cardiopulmonary bypass surgeries to cool patient blood in order to preserve brain tissue longer. Current (HCDSs) are bulky and prone to housing bacteria, risking patient infection in the operating room. The Penn State College of Medicine tasked the team with developing an innovative solution that could eventually be implemented in operating rooms.

Objectives
The 3D printed heat exchanger must decrease blood temperature from 37°C (body temperature) to 16°C in pediatric patients, by no more than 10°C at a time, and then rewarm the blood at the end of surgery. This device must also prevent coagulation of the blood as it travels through the system, be compact in size (about 1 ft³), disposable after each patient use, and prevent bacteria from growing in it during use.

Approach
- Traveled to the PSU College of Medicine to meet with the sponsor and various surgeons that use heater-cooler devices during operations to discuss desired changes
- Concept generation resulted in 3 major designs throughout of the semester that were designed and completed in SolidWorks
- 3D printed Design 2 in the Learning Factory with a thermoplastic
- 3D printed Design 3 (final design) by outsourcing through 3D Systems in PC/ABS
- Met with Dr. Tak-Sing Wong who invented the SLIPS Technology for biocompatibility
- Received samples of 3D printed stainless steel parts from Dr. Tim Simpson
- Attempted studying the final model in COMSOL
- Produced a final procedure that could be followed for future testing of the model for biocompatibility and bacterial presence

Outcomes
- The model consists of capillary blood tubing, a water chamber, and an outer chamber filled with phase changing materials to increase the efficiency of the device
- The final product is 12 in. x 6 in. x 6 in. and disposable, meeting design specifications
- $116 was used for the poster and printing of the final design in PC/ABS
- 3D printing the model with stainless steel and heat resistant resin costs about $3,000