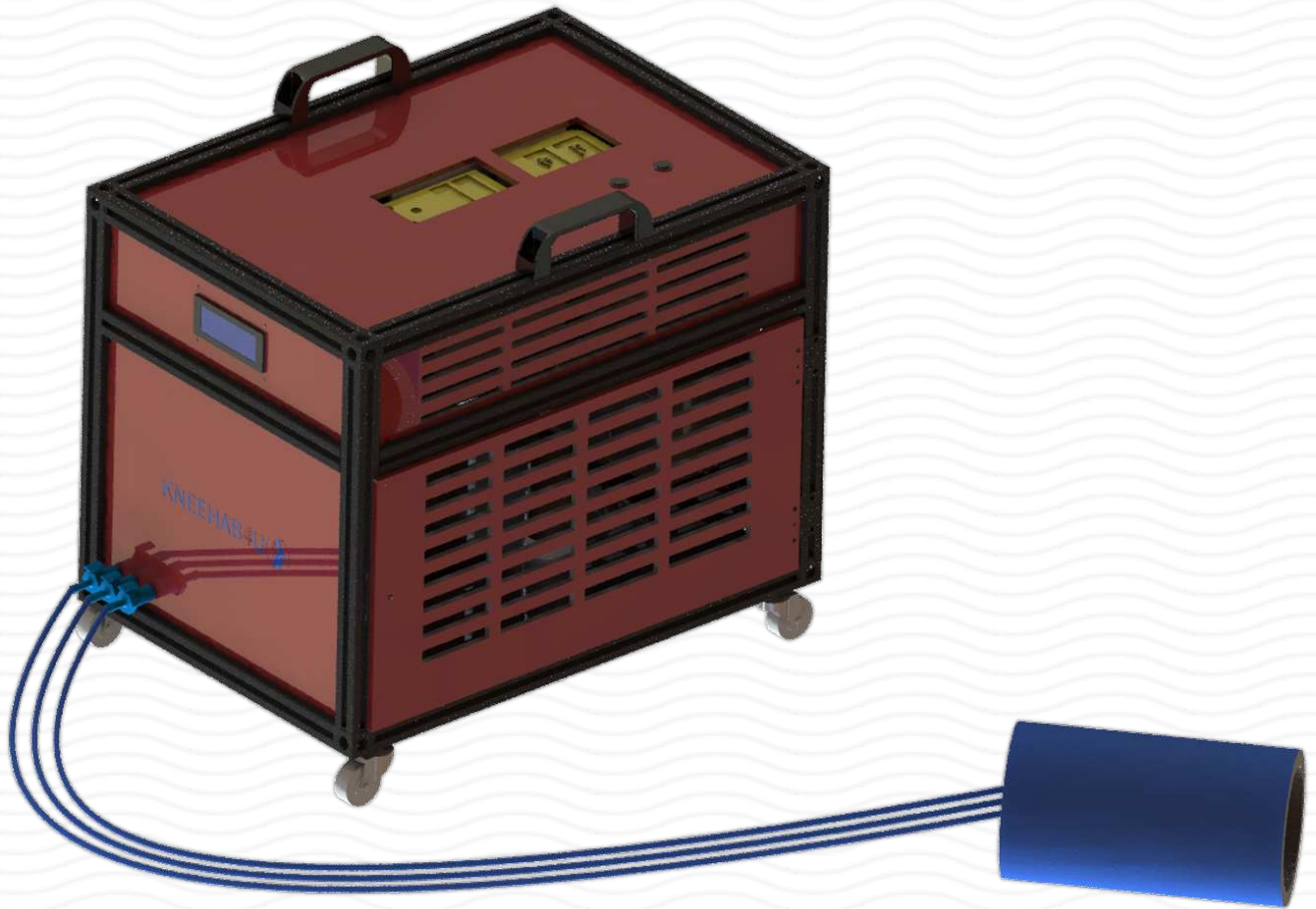


KNEEHAB4U



**Get Back To Doing
What You Love**



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Our Story

Kneehab4U's journey began in the 2019 Fall Semester of the mechanical engineering capstone course at the University of Colorado, Boulder. The team brainstormed issues that hit close to home, to which the team found multiple members underwent ACL surgery. This revealed a need for a post-operative knee recovery device that is effective, affordable, and shows the importance of following post-op therapy. The team researched what therapies were effective in the recovery process. The team found that compression, cooling, heating, and the usage of nerve stimulation provided the best aid in terms of recovery and comfort. With this information, The team had the functionalities the device would need to utilize along with an application to control all functionalities and track the usage allowing the users and care providers to see the time put into recovery and the associated results. With these in mind, the team started designing the product which would later be named the Knee4tifier. The design needed to be cost-efficient while still delivering a quality product. The team was able to complete the assembly process of the product and was in progress of full system integration when all work halted due to COVID-19. Ultimately, the team was able to run all the device functionalities and showcase a skeleton design providing a proof of concept.

The Team



Mohammed Alwakeel
Project Manager
B.S. Mechanical Engineering
Minor in Business Analytics



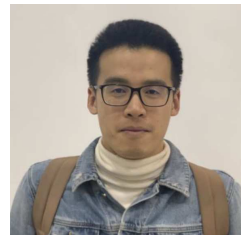
Isaac Gwa
Financial Manager
B.S. Engineering Plus Mechanical
Minor in Engineering Management



Joseph Coulombe
Logistics Manager
B.S. Mechanical Engineering
Minors in Leadership and
Engineering Management



Abdulrahman Alharbi
Test Engineer
B.S. Mechanical Engineering



Yizhou Chen
CAD Engineer
B.S. Mechanical Engineering
Minors in Applied Mathematics and
Control Systems



Project Goals



Kneehab4U recognizes the need for progressive rehabilitation following orthopedic surgeries; specifically Anterior Cruciate Ligament (ACL) surgeries. The team developed a post surgery cold therapy device that replaces traditional ice pads. Our device integrates compression, cooling/ heating, and Transcutaneous Electrical Nerve Stimulation (TENS). Compression provides better blood flow around the afflicted area, cooling/ heating reduces inflammation and helps muscles relax. Lastly, TENS helps relieve pain felt by the nerves.

Currently, two types of cold therapy devices are in the market. There is an affordable option that requires adding water and ice every 2-3 hours to keep cold water running through the pad. On the high-end there is an expensive product that offers additional temperature control and compression therapy. The goal is to stand out from our competitors by offering the high end features at an affordable price range. The novelty of the project is the addition of the TENS unit along with the smart technology (Internet of Things) that lets the user control and monitor the progress at their fingertips.

The device benefits patients by providing full control over the recovery progress and the integrated smart technology allows patients to monitor their progress as well. Researchers will also benefit from the device as it is capable of capturing the patients' data, which will allow further studies of the recovery process.

Team Goals



The team explored several goals as they dived into the project. The team desired to become more technical in designing and in developing the product. We are aspiring engineers and this full scaled product developing project has become a platform for the team to learn and grow as engineers in a professional setting. We wanted to experience the process of designing a functioning mechanical device and communicating the design intents to our client. Moreover, we wanted to learn how to work in a team and communicate effectively. As we develop the product, the goals of the team become more apparent.

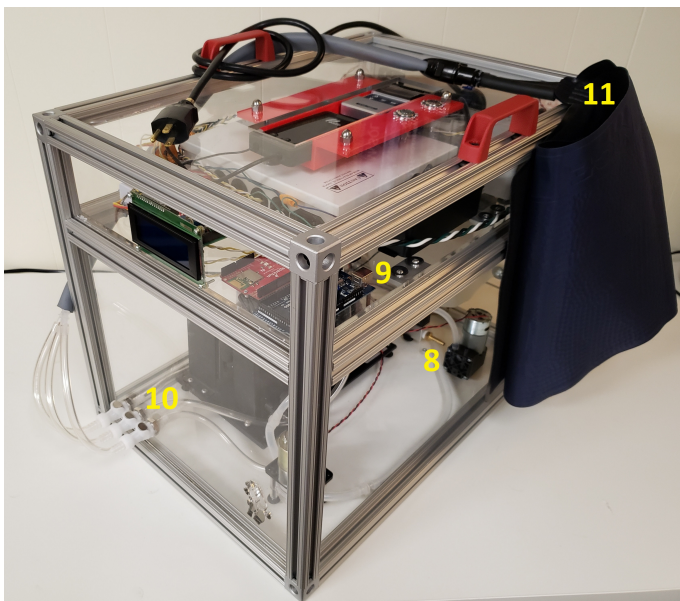
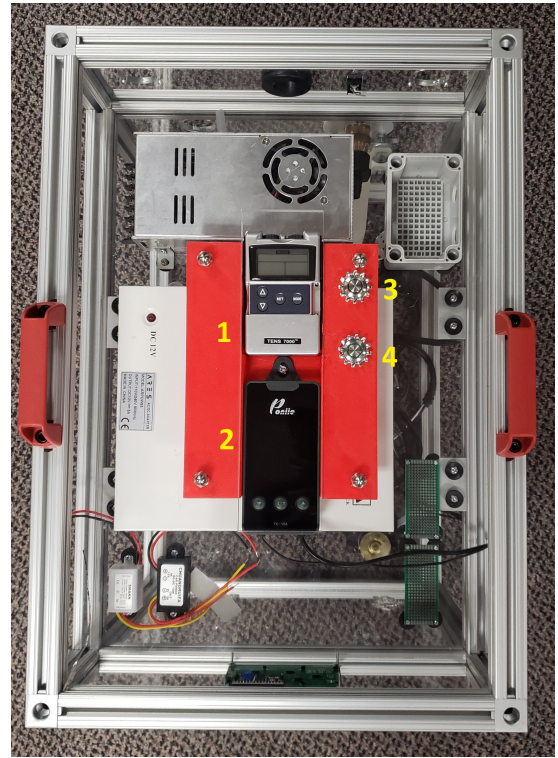
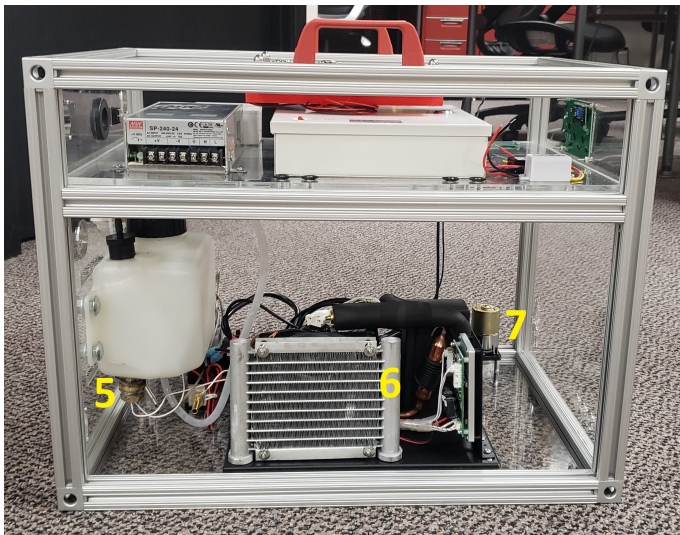
The goal of the team includes documenting the project for communication, future recommendations, and design validation. The team was interested in developing and progressing soft skills revolving around leadership and management. This also included being well rounded and willing to help each team member with their workload when it became overwhelming.

Our motivation throughout the school year developed from this project symbolizing the accumulation of our time and effort in the mechanical engineering program showcasing what it means to be a Mechanical Engineering undergrad from the University of Colorado, Boulder.



How It Works

The **Knee4tifier** is smaller than the average computer tower and is connected to a knee wrap to apply to the user. The user can control the temperature of the water, intensity of the TENS, as well as the compression mode from the top panel.



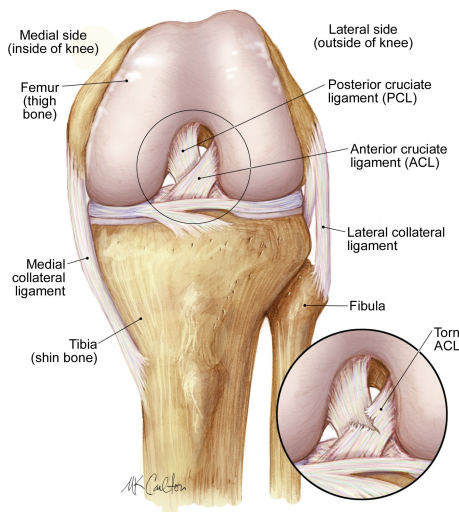
The numbers included on the pictures correspond to the following components:

1. TENS Unit
2. Thermostat
3. Emergency Shutdown
4. Compression Mode
5. Heating Unit
6. Cooling Unit
7. Water Pump
8. Air Pump
9. Control System
10. Quick Connects
11. Knee Wrap

*These photos show the device without wiring to show critical components



How It Helps



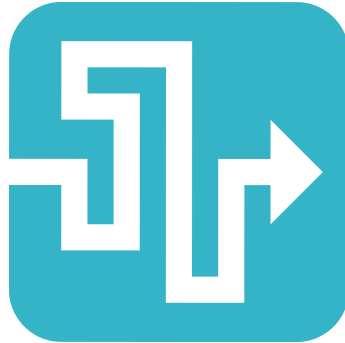
ACL tears typically happen after an individual pivots suddenly causing the ligament to rip or be disconnected from the bone. These injuries do not heal on their own and require surgery to replace the ligament with a tendon somewhere else in the body. After going through ACL reconstruction the patient needs to reduce swelling which occurs around the knee as well as combating atrophy of their muscles. The Knee4tifier provides various stimulation to improve the users recovery progression overall.



To reduce the swelling in patients the device utilizes cooling to the affected area. Compression is utilized to increase blood flow to aid in the body's natural healing ability. Once swelling has decreased using heat can be used to also increase blood flow. During this process the patient can experience a lot of pain. To alleviate the pain the device utilizes a TENS unit that applies small electrical impulses that overload the nervous system restricting pain signals from going to the spinal cord and brain.



Challenges



Knee4tifier proved to be a very challenging project. Not only did the team need to worry about patients' safety, but also the project had over 120 elements that required over 70 CAD drawings to ensure that the purchasing and the manufacturing process run smoothly. The project consists of various technologies and hardwares needing to be integrated and acquired from various vendors including imported parts.

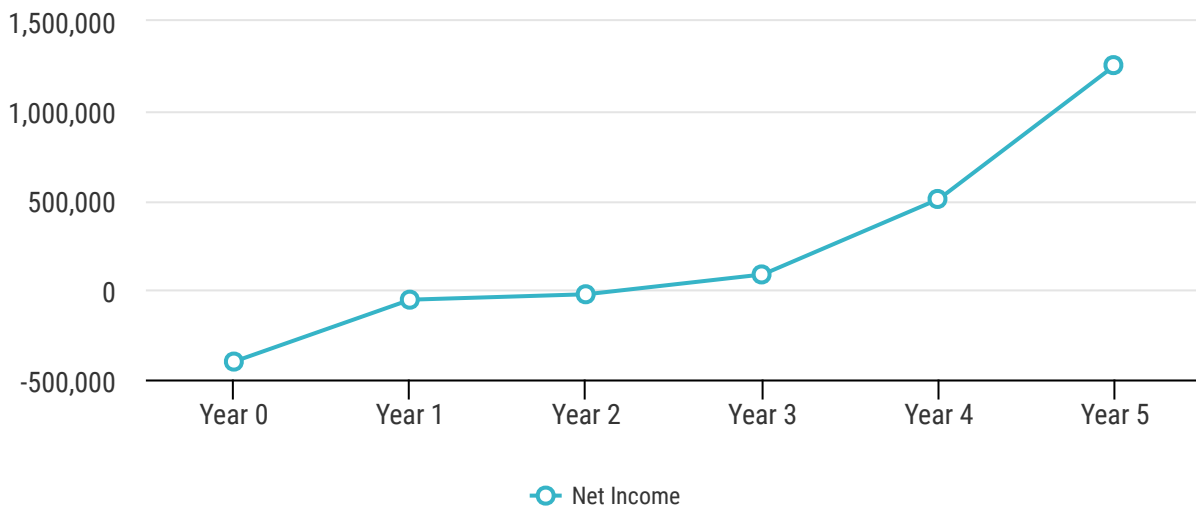
Therefore, from a technical perspective, the integration of multiple components into one large complex system was challenging. Such complexity required the team to work on things that are outside of their knowledge boundary; such as coding for the whole system to work cohesively with dependencies upon feedback data from the sensors.

Some of the non-technical challenges that the team faced include communicating effectively, finding a time where all team members are available to meet, and staying motivated throughout the course of the project. The team has overcome these difficulties by spending more time in the meetings to ensure that all team members are in agreement and by agreeing on a preset weekly meetings times at the beginning of each semester.





Knee4tifier Profit Margin Forecast



KneeHab4U recognizes the need for further research & development in the device for it to launch in the market. The team plans to gradually increase in marketing and R & D for higher revenue by the end of year 5. KneeHab4U will break even between year 2 and year 3 after 589 units are sold and the return on the investment is 36% for the 5 years. The initial investment needed to launch the company is \$478,800 for two years.





Team Growth

Senior Design created an environment for the team to apply the knowledge learned in previous courses. Being able to experience the product development process broadens our perspective on ideation, designing, building and testing to develop a final product that is ready for use. Each phase required applying the knowledge learned in previous courses.

For instance, the team applied heat transfer equations to calculate the heat loss in our system. The team also used our understanding in thermodynamics to ensure no condensation occurs on the exposed side of the tubes or the pad as well as in the electrical compartment. This gave the team an in-depth experience on how theories are applied in real world applications. The team learned to pay attention to small details, avoiding possible failures if left unattended.

On a personal level, the team learned to communicate with clients, vendors, and professors in a professional manner developing lasting and positive relations. The team improved on time and stress management and building contingency plans. A soft skill that we developed is conflict resolution, which was essential to work with a team of different backgrounds.

