James Dyson Foundation Undergraduate Bursary 2018/19
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Outreach Report
Biomedical engineering: Prosthetic leg activity

The activity I lead was a prosthetic leg design, manufacture and test exercise. The session began with a short PowerPoint introduction to prosthetic legs and different design considerations to take into account when making a high performance sports leg, an everyday use NHS leg, or a low cost, easily manufactured leg for distribution in developing countries. There was some engagement with the students in this presentation regarding the difference in these design criteria for each use.

Some design criteria discussed at this stage were:

Weight	Lightweight for sports but also for everyday use; don't want to fatigue the wearer.
Material properties	Needs to be stiff and strong for sports but we also require long-lasting durable prosthetics which are resistant to fractures and wear and tear for everyday use.
Ability to handle different loading patterns	High impact loading for sports vs. fatigue loading for everyday wear and tear. Everyday design also needs to be able to handle higher impact loading in some situations.
Ease of attachment/ detachment	Need fast and easy attachment for everyday leg so wearer is independent. Specialised sports prosthetics can maybe take longer/require a helper for more infrequent use.
Cost	Require low cost for everyday prosthetics so people can afford them – NHS cannot fund very expensive ones for everyone. Competitive sports may have more money to spend on individual prosthetics.
Lifelikeness	Everyday prosthetics need to be suitable for use with normal clothes e.g. fit with trousers/tights/normal shoes. Whereas, specialised sports prosthetics may not need to be worn with shoes as this will change the design – not as lightweight or easy to manoeuvre.

For the task, students were split into groups of 3 and provided with the following materials:

- Cardboard
- Bamboo sticks
- Tape
- Glue guns
- A sponge
- String
- Scissors
- A ruler

- A boot

The sponge was provided for cushioning between the knee and the prosthetic, such that the user would walk with one knee resting on the leg. The two team members not wearing the leg would help balance the wearer. The “foot” of the leg was to fit into the boot to allow walking, whilst the top of the leg was allowed to be taped to the wearer’s knee to keep it attached whilst moving.

The intention was to assess each leg by calculating a metric of how far the student could walk on it, divided by the mass of the leg. In this way, heavier legs would be penalised and legs which could carry the students’ weight comfortably for longer would be beneficial. However, there was not enough time to measure these criteria and hence this metric was not calculated and compared for each group.

Bamboo sticks were initially cut roughly to size but if they needed to be made shorter to fit the students’ legs, Kevin was on hand with the band saw.

The most successful design was a triangular prism shape made using cardboard. This fitted into the boot well and was sturdy for walking. Most groups, however, were excited to use the bamboo and went straight ahead with strapping all the sticks together before thinking much about how that would fit in the boot or how the sponge would be fitted to the top to allow someone to rest their knee on it. These bamboo designs tended to be unstable and not take the student’s weight. Whereas, the larger surface area of the cardboard prism interface with the sponge and knee allowed for a far more stable design. Many of the less successful teams could not put any weight through the leg and instead hopped along the path.

One major drawback of the session was the lack of time set aside to complete it: the day was running behind schedule and as such, students were only allowed 10 minutes to design and build their legs. Ideally, I would allow 5 minutes without touching the materials for the groups to make a design and think about how it would balance and if they were making use of all the materials they wanted. Then, 15 minutes to build, 5 minutes to test and 5 to come together as a group and discuss which worked well and why. Unfortunately there was no time in my session to have this final discussion which I think would have been useful for analysing why some legs were so unstable. As mentioned above, more time would also have allowed for the calculation of the metric of distance walked/weight of the leg which would help demonstrate and quantify how lightweight legs are beneficial for prosthetic use.

I also think it would have been useful to have a concluding discussion regarding the design criteria introduced at the start and how each group addressed these with their design. This would have helped tie in some basic engineering design concepts through the whole activity. Overall though, I believe this session was successful and the students very much seemed to enjoy the freedom of designing their own leg from scratch.