Prototyping a transdisciplinary bioengineering curriculum development project

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Abstract

- Biomedical engineering is transdisciplinary
- Students must be able to integrate concepts across domains to tackle biomedical problems
- Traditional curricula do not reflect this: students tend to over-compartmentalise concepts & engage in surface learning
- Applied design-based research framework to redevelop curriculum around collaborative student-led design of a bionic limb
- Implementation in 2 subjects to date has garnered positive student feedback

Background

- Biomedical engineering is **transdisciplinary**
  - "Integration of multiple disciplines in a way that transcends their traditional boundaries" (Khoo, Haapakoski, Hellstén, & Malone, 2019)

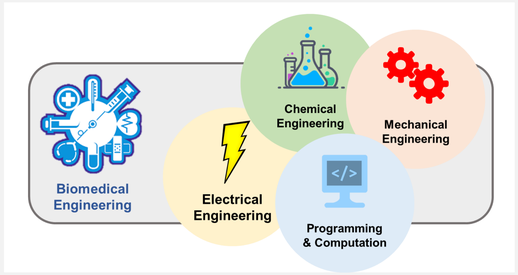

Figure 1: The trandisciplinary nature of biomedical engineering.

- Previous curriculum did not reflect this (little to no cross-subject references/connections)
  - Students tend to over-compartmentalise concepts
  - Students tend to engage in surface learning
- Aims/Objectives:
  - Help students make connections between concepts & across subjects
  - Promote deep learning through hands-on collaborative design work
  - Enhance the overall learning experience

Methods

- **Framework:** Design Based Research (DBR)
  - Continuous iterations of design, deployment, reflection, and redesign

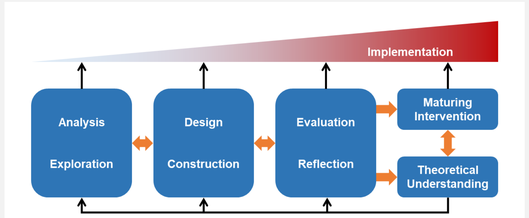

Figure 2: DBR framework (adapted from McKenney & Reeves, 2020).

- **Approach:** Redevelop curriculum around a bionic limb design project
  - Inspired by work done in a previous subject exploring the integrated learning of mechanics & programming concepts

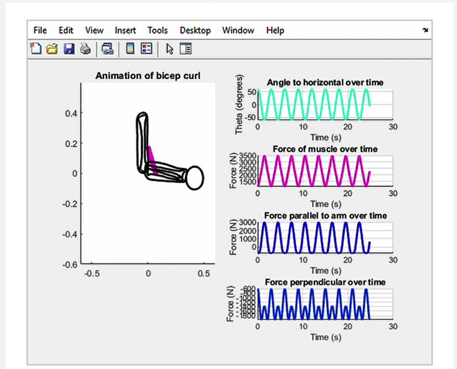

Figure 3: Assignment centred around the simulation and animation of a bicep curl, integrating mechanics & programming concepts.

  - Students explore engineering sub-systems of the bionic limb in different subjects, focusing on connections & how parts contribute to a whole
    - **Problem-based learning:** promotes independent & profession-aligned learning (Biggs & Tang, 2011)
    - **Constructionism:** knowledge & connections between concepts actively constructed through creation & collaboration (Papert & Harel, 1991)

Progress

- Formed curriculum design team aligned with core subjects & bionic limb sub-systems

Table 1: Alignment of subject focus areas & relevant bionic limb sub-systems.

Subject	Focus Area	Sub-system
BMEN20003 Applied Computation in Bioengineering	User-bionic limb interfacing, programming & simulation	Translation of user inputs into motion outputs
BMEN30006 Circuits and Systems	Actuation & control of limb motion	Electronics & circuitry
BMEN30010 Mechanics for Bioengineering	Material design & fabrication, mechanics of limb motion	Physical structure of bionic limb
BMEN30008 Biosystems Design	Engineering design & analysis principles	Feasibility studies, safety & risk analyses, assembly

- Staging of information is important
  - Students encounter BMEN20003 first, then BMEN30006 & BMEN30010 concurrently, and finally BMEN30008
  - Subject assessments designed to account for this & to foreshadow connections to future concepts
- Prototyping of bionic limb by tech designers
  - Revealed challenges likely to be faced by students
  - Informed design of accompanying scaffolded learning activities

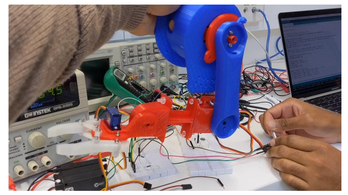

Figure 4: Functioning bionic limb prototype.

- Bionic limb-related learning activities launched in 2 subjects to date
  - **BMEN20003**
    - Bicep curl simulation (Figure 3) adapted for delivery
    - Subject altered to incorporate concepts drawn from a diversity of bioengineering-related fields (e.g. electromagnetism, systems biology)
  - **BMEN30010**
    - Activities modified to promote recall of knowledge covered in BMEN20003
    - Established project-based team assignments requiring synthesis of mechanics & computation (along with scaffolded accompanying tasks)

Conclusion

- Positive preliminary student feedback

"It is a fantastic concept and I love the idea that unit coordinators are **working together as a specialisation rather than isolated units**. I think it's great our coordinators are working together to **integrate content**. Overall, I think the collaboration is fantastic and **something that we should do throughout our degree to bring skills together.**"

- **Reflections**
  - COVID-19 restrictions adversely affected student interactions & collaborations
  - Difficult to alter students' approaches to learning due to length of semester (12 weeks) – likely to observe changes in longer term
  - Formal evaluations (surveys & focus groups) planned for upcoming semesters
  - Ecology of resources to be expanded (ePortfolios)

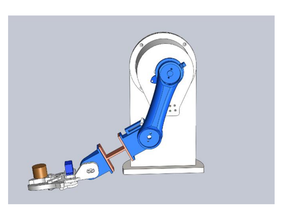

Figure 5: CAD schematic of bionic limb prototype.

Please scan QR code for more information.

References

- Biggs, J. & Tang, C. (2011). Teaching/learning activities for functioning intended learning outcomes, In *Teaching for Quality Learning at University* (pp. 160-190). Open University Press.
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ASCILITE 2021

Funding & Support: Rajagopal, John, Davey, Lam. The bionic limb project: enhancing student learning through project-based learning in bioengineering. *Learning & Teaching Initiatives, Chancellery (Academic), University of Melbourne.*