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# **Rehabilitation Engineering Universal Design Challenge**

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## **Abstract**

This paper will discuss the integration of universal design as part of a module on Rehabilitation Engineering in the undergraduate and masters Biomedical Engineering programmes at University College Dublin (UCD). The module introduces students to the field of Rehabilitation Engineering through a combination of lectures, assignments, and practical exercises. Students are based in UCD, Belfield and the National Rehabilitation Hospital, and receive lectures from faculty at UCD and a number of clinical guest lectures from organizations including the Centre for Universal Design at the NDA, the National Rehabilitation Hospital, Enable Ireland, and Spinal Injuries Ireland. A key component of the module is a Universal Design Challenge in which students are required to develop initial concept design solutions over 24-48 hour period. Students are asked to design a product that will address identified user needs arising from a disability that typically includes diminished strength, dexterity, mobility, sensory function and/or communication. The primary output is a new or redesigned product, tool or device that has the potential to make a significant difference to the user and to enable their ability to access the world. Projects are assessed on the ability of the design concept to meet the expectations defined with specific principles of Universal Design. The module and the incorporation of a Universal Design component requires students to focus on user needs and enables them to interact directly with patients, user groups and clinicians.

## **Introduction**

This paper will discuss the integration of universal design as part of the Rehabilitation Engineering module which forms part of the undergraduate, BE, and masters, ME, programmes in Biomedical Engineering at University College Dublin (UCD). The module is also taken by students of the Masters in Medical Device Design at the National College of Art and Design. The module was developed originally as a component of an All-Ireland MSc in Bioengineering and has evolved over the past 10 years into its current format.

Participating engineering students are in the final year of their undergraduate or masters degree in biomedical engineering. They have completed a foundation in electronic and/or mechanical engineering, followed by a gradual move towards specialisation in biomedical engineering through interdisciplinary modules including Biomedical Signal and Images, Bioinstrumentation, Medical Device Design, Biomechanics, Biomaterials, Cell Culture and Tissue Engineering, and Neural Engineering. In preparation for these modules they are also required to complete modules in Physiology and Basic Medical Sciences for Engineers which adopt a system level approach to physiology and anatomy.

Following graduation, the majority of students take up employment within the medical device or technologies industry or to pursue post-graduate research.

## Rehabilitation Engineering Module

The aim of this module is to introduce students to the field of Rehabilitation Engineering, which is defined here, following the approach of Dr. James Reswick, as ‘the application of science and technology to ameliorate the handicaps of individuals with disabilities’<sup>1</sup>. The module begins with an exploration of what is meant by the terms ‘impairment’, ‘disability’ and ‘handicap’. The concept of ‘person-first’ language is introduced along with formal methods for assessing disability, including the Activities of Daily Living and Instrumented Activities of Daily Living scales. Through this, students are introduced to the International Classification of Functioning, Disability and Health (ICF)<sup>2</sup>. This emphasizes the idea that disability is something that can be experienced by all individuals to various degrees at different times of their lives and sets the background for Universal Design as an approach that can benefit all.

In preparation for specific topics that will be addressed later in the module, common medical conditions that result in disability and associated clinical symptoms and complications are presented. The challenges that will arise from an aging population and increased prevalence of obesity are also discussed.

Students learn about the principles underpinning Rehabilitation Engineering through a combination of lectures, assignments, and practical exercises. The module is delivered in an intensive 5-day format, during which students participate in lectures, lab work and design exercises. The lectures and laboratory work take place across the Engineering facilities at UCD, Belfield and at the National Rehabilitation Hospital, Dun Laoghaire.

Students receive lectures from faculty at UCD and a number of clinical guest lectures from organizations including the Centre for Universal Design at the NDA, the National Rehabilitation Hospital, Enable Ireland, and Spinal Injuries Ireland. The topics covered vary slightly each year, but typically include prosthetics and orthotics, seating and wheeled mobility, neurorehabilitation, clinical rehabilitation, movement analysis and connected health. In addition to academics and clinicians working in specific areas of rehabilitation engineering, representatives from user support groups are invited to speak to students about their own experiences and those of their members. Guest speakers for the module in 2015 included Joan Carthy, a founder of Spinal Injuries Ireland and more recently, Peer Support Ireland, an organisation that provides support and information to people with a spinal cord injury and their families, and Tina Lowe, the Disability Access Officer for UCD, who spoke about the needs of students on campus in addition to her own experiences as a person with a visual impairment. Feedback from students has indicated that they find this part of the module to be of particular benefit as it provides insight into the user experience and the particular challenges that individuals with disabilities encounter during their day to day activities. It also has a strong impact and informs the decisions that the students make during the Universal Design Challenge.

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<sup>1</sup> Enderle, J. D. and J. D. Bronzino, Introduction to biomedical engineering, 3rd ed. Burlington, Mass. ; London: Elsevier : Academic Press, (2012).

<sup>2</sup> World Health Organization., "International classification of functioning, disability and health ICF," in International classification of functioning, disability and health ICF, 1.0. ed. Geneva: World Health Organization, (2001), 1 CD-ROM.

## **Universal Design**

A key component of the Rehabilitation Engineering module is a Universal Design Challenge in which students are required to develop initial concept design solutions that build on the core principles of Universal Design. Students combine these with relevant principles from engineering, information and communication technology and/or clinical practice to address clearly identified user needs/issues. The design challenge is run with considerable assistance and collaboration from the Centre for Excellence in Universal Design (National Disability Authority). Towards the beginning of the module, students participate in a workshop on Universal Design which is delivered by James Hubbard of the Centre for Excellence in Universal Design at National Disability Authority, Ireland. The two hour workshop introduces students to the 7 principles of Universal Design (UD): (1) Equitable Use, (2) Flexibility in Use, (3) Simple and Intuitive Use, (4) Perceptible Information, (5) Tolerance for Error, (6) Low Physical Effort, (7) Size and Space for Approach and Use<sup>3</sup>. Diversity among the population is explored and the legal rationale for the consideration of universal design against the background of the Convention on the Rights of Persons with Disabilities (United Nations 2008) is explored. The principles of UD are demonstrated through real-world examples of good and bad designs for individuals with diverse abilities. The students are provided with data sheets from the Centre for Excellence in Universal Design on designing for diverse body sizes and shapes.

### **Universal Design Challenge**

The Universal Design Challenge is an intensive group design exercise that pushes randomly assigned teams of engineering and design students to develop solutions within a time-constrained environment.

Teams are assigned a different ‘challenge’ or topic each year and are required to develop initial concepts for design solutions that build on the core principles of Universal Design and combine these with relevant principles from engineering, information and communication technology and clinical practice to address clearly identified user needs/issues. Students are asked to design a product that will address key requirements arising from a disability that typically includes diminished strength, dexterity, mobility, sensory function and/or communication. The primary output is a new or redesigned product, tool or device that has the potential to make a significant difference to the user and to enable their ability to access the world.

Students work together over a 24-48 hour period before presenting their solutions to an assessment panel comprised of academic staff, clinicians and users. Projects are assessed on the ability of the design concept to meet the expectations defined with specific principles of Universal Design, and are graded on the criteria used for the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) student design competition. Aside from periods during which the UCD campus buildings are not available, teams are allowed to spend as much time working together within the Engineering Building as they feel is required.

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<sup>3</sup> The Principles of Universal Design, NC State University, The Center for Universal Design (1997).

At the end of the challenge, students are required submit a summary report outlining their design solution and to present a pitch of their design concept to students and an invited panel of judges for assessment. The assessment is based on specific criteria including the overall representation of the application of the Principles 1, 2, 3 and 6 from the 7 Principles of Universal Design. At least 3 of the 7 UD Principles should be explicitly addressed in the design. The summary report is graded on the criteria used for the Rehabilitation Engineering and Assistive Technology Society of North America (RESNA) student design competition, and is required to contain the following information:

- a) Abstract/Background/Statement of Problem or Research Question
- b) Methods/Approach/Solutions Considered
- c) Results/Resolution/Discussion/Outcome/Performance & Cost/Implications
- d) Clearly presented product concept – ideally some form of story-board or other schematic that illustrates the product concept.
- e) Overall Quality of Presentation
- f) Demonstrate how the subject matter is timely and appropriate to the target audience

The Universal Design Challenge comprises 40 % of the total marks for this module, with the remaining 60 % assessed through a final exam.

### **Topics and outcomes**

In recent years topics that have been addressed include ‘Navigation and Way-finding on Campus’, ‘Accessing the World Through Technology’ and ‘Ageing Related Functional Impairment – Everyday Consumer Products’. For the 2015 Universal Design Challenge, the following suggestions in the area of ‘Mobility and Navigation’ were provided as a starting point for students:

#### **(i) Mobility**

Wheelchair users of both manual and powered chairs experience many challenges in their day to day lives. Many experience varying levels of control over their trunk, arms and hands depending on level of injury or underlying condition.

Some of the day to day challenges which wheelchair users experience include maintaining safe & good posture in their chair, maintaining comfort in their chair, including the ability to shift their bodies in their chair to avoid serious complications such as bed sores, and difficulties interacting with the physical environment and physical products with control and accuracy

The brief is to develop new concepts that address and aim to reduce or even eliminate these issues for the wheelchair user, concepts which will enhance the quality of life for the wheelchair user.

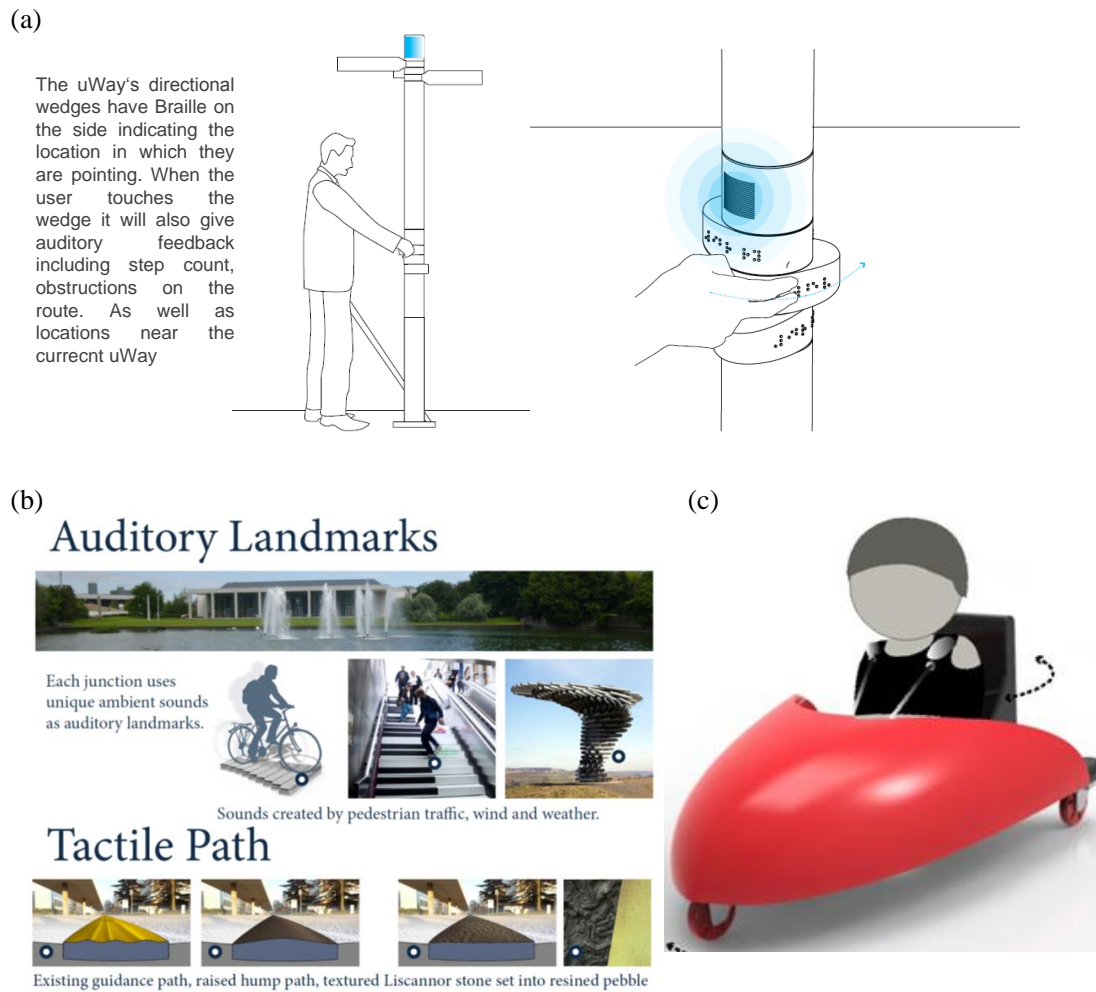
#### **(ii) Navigation and Way-finding**

UCD is located on a 133-hectare campus providing a mix of academic facilities, research institutes, libraries and archival collections, enterprise space, student villages, and sports and recreational facilities. The campus accommodates over 30,000 students and staff, including over 6,000 international students, wheelchair users and individuals with visual impairment.

Way-finding (how people find their way around environments) and navigation (around barriers) of the campus and location, and access to, specific lecture theatres or facilities can be extremely difficult, even for those with a good knowledge and familiarity with the campus. Existing signage is sparse in many places and is not accessible to many users.

The brief is to develop new concepts that address and aim to reduce or eliminate these issues for staff, students and visitors with disabilities, concepts which will open up the campus and make it possible to be independently navigated and accessed by all.

Concepts illustrating three of the solutions proposed by the groups in 2015 are presented in Figure 1.



**Figure 1:** Illustrations presenting the design concepts from three groups for the 2015 Rehabilitation Engineering Universal Design Challenge (a) ‘U-way’ wayfinding system (b) Solution incorporating tactile maps, tactile path and auditory landmarks (c) Toy designed for a child with total amelia to enable him to play and exercise.

### Benefit to students

The Rehabilitation Engineering module is the only opportunity that many students have to interact directly with clinicians, patients and user groups during their engineering education. It increases their awareness around disability and the responsibility of engineers to consider the needs of all individuals. From feedback on the module, it is clear that students appreciate the opportunity to engage with patients and clinicians and to move outside the class-room

environment. Students also reported that participation in the module changed their perspective. When asked to identify the best aspects of the module, students reported ‘connection between real human physical issues and engineering world’, ‘clinical relevance’ ‘real world examples and case studies’, ‘human aspects’, ‘seeing how this course benefits patients’, ‘understanding the user/client concerns’, ‘putting a human face/issues to engineering’.

The Universal Design Challenge is universally reported to be an enjoyable and positive learning experience. The following student feedback is representative of what is reported by students ‘The 24hr group design project was a lot of fun, and an invaluable exercise to undergo. I feel that undergrads should be made perform this type of project every month or so as it was a terrific experience and extremely useful.’

### **Conclusions**

The UCD module in Rehabilitation Engineering enables biomedical engineering students to engage with practical engineering approaches to alleviating some of the challenges faced by individuals with disabilities. A unique aspect of the module is the opportunity that students have to interact directly with patients and clinicians in order to understand the needs of both groups. Experience over the past decade has highlighted the need to keep the module content current, particularly in the context of rapid changes in assistive devices, technology and communications. The Universal Design Challenge represents an important part of the module providing the students with the opportunity to address real-world challenges using a systematic design approach, and working in teams of designers and engineers. It is envisaged that the Universal Design Challenge will remain a central component of the module as it evolves over the coming years.