ENGINEERING EMPATHY: USING PERSON CENTRED SIMULATION TO FOSTER INCLUSIVITY IN ENGINEERING DESIGN

Kathryn Fee, Aislinn McAleenan, Matthew Cairns

School of Mechanical & Aerospace Engineering, Queen's University Belfast

Gerard Gormley

School of Medicine, Dentistry, Biomedical Sciences, Queen's University Belfast

ABSTRACT

Utilised heavily within medical education, person-centred simulations have now emerged as a powerful methodological and pedagogical tool for integrating end user perspectives into engineering design processes. This is particularly important when facilitating the development of empathy within design, which is a difficult element to replicate within the classroom environment. Using a person-centred approach, an ageing simulation workshop was designed for mechanical engineering and product design engineering students, with the aim of aiding the development of empathy to enhance their ability to design devices for *all* individuals. Over the course of a three-hour workshop, students were split into groups with each group given a different scenario. Using GERT ageing suits and other devices, that mimicked mobility, hearing and visual impairments, students carried out several tasks based on their given scenario. Students were asked to identify challenges they faced while conducting the tasks within their scenario. Following a structured and evidence based debrief, each group had to isolate a specific challenge and come up with design concepts to solve that problem. This workshop brought a different dimension to both the module and the student's way of thinking. It challenged the students in their abilities as engineers while emphasising the importance of empathy in design.

KEYWORDS

Person-Centred Simulation, Empathy in Design, CDIO Standards 1, 5, 7, 8

INTRODUCTION

Utilising simulation models is customary in engineering education and practice. However, with computational simulation there is a level of detachment from the most important stakeholder – the end user. Efforts to embed empathy and stakeholder engagement within engineering education span a wide range of approaches. Some focus on immersive design activities that connect students directly with the users for whom they are creating products for. However, providing this experience in a meaningful way can be difficult to achieve, especially when the needs of the end users can vary significantly. Others take a broader view, encouraging students to reflect on empathy in the context of engineering ethics by considering the perspectives of people who are not physically present and integrating those viewpoints into their decision-making processes (Sochacka *et al*., 2020).

In medical education, person-centred rather than computational simulation has been utilised for several decades. It enables trainee health care professionals to gain experience with (simulated) patients in a simulated environment while being shielded from real-world consequences (Vage *et al.,* 2022). It has also been documented that simulated experiences of ill-health have helped health professionals demonstrate a greater empathy towards their patients (Karvelytė *et al*., 2021). This has become recognised within biomedical engineering education, and it has been documented that experiences gained through clinical immersions promote user-centred design processes in biomedical engineering students (Singh *et al.,* 2019).

Through person-centred medical simulation activities, the aim of this workshop was to nurture mechanical engineering and product design engineering students to develop empathy in design to enhance their ability to design devices for *all* individuals.

WORKSHOP DESIGN

Background

In the final year of their degree programme, MEng students in mechanical engineering and product design engineering have the option to take an elective module Advanced Materials. This is a year-long module, split into two themes, (1) Advanced Metal-Based Materials (2) Biomaterials and Medical Devices. The aim is for students to develop competence in advanced materials and their applications in engineering. This is the first opportunity for the students to explore biomedical engineering applications in depth. A variety of learning resources were utilised within the module, with different formats of tutorials and discussions used but there was no ‘hands on practical/experimental’ element.

It was important that this workshop provided a different dimension to what the students had already experienced within their degree. While empathy is one of the first stages of the design thinking process, it can be difficult to give students the opportunity to observe and consult with potential end users, particularly when it comes to product development for biomedical applications, where individual needs and abilities are personal and vary significantly. Therefore, it was key that this workshop captured that aspect.

The concept of person-centred simulation is a method that has been utilised by colleagues in Medical Health Life Sciences (MHLS) for several years. Drawing on the methods used by MHLS, this approach was adapted to suit engineering students. Trainee medical professionals are put in the position of a simulated medical emergency, and they must treat the patient. As

engineering students do not treat patients but instead design products to enhance their day-to-day living and wellbeing, it was decided the students would take on the role of the 'patient'.

Format

Employing the expertise of colleagues in the KN Cheung SK Chin InterSim Centre in the School of Medicine, a three-hour workshop was developed. Due to access to facilities, availability of facilitators and the desire to have small group sizes, the class (n=27) was split into two groups, and the workshop was delivered twice. All conditions for both workshops were the same. For ease of adaptation, the person centred simulations were based on ageing, incorporating mobility, visual and hearing impairments.

The workshop had two core themes, the first half was the ageing simulation, and the second half was the design challenge (Figure 1).

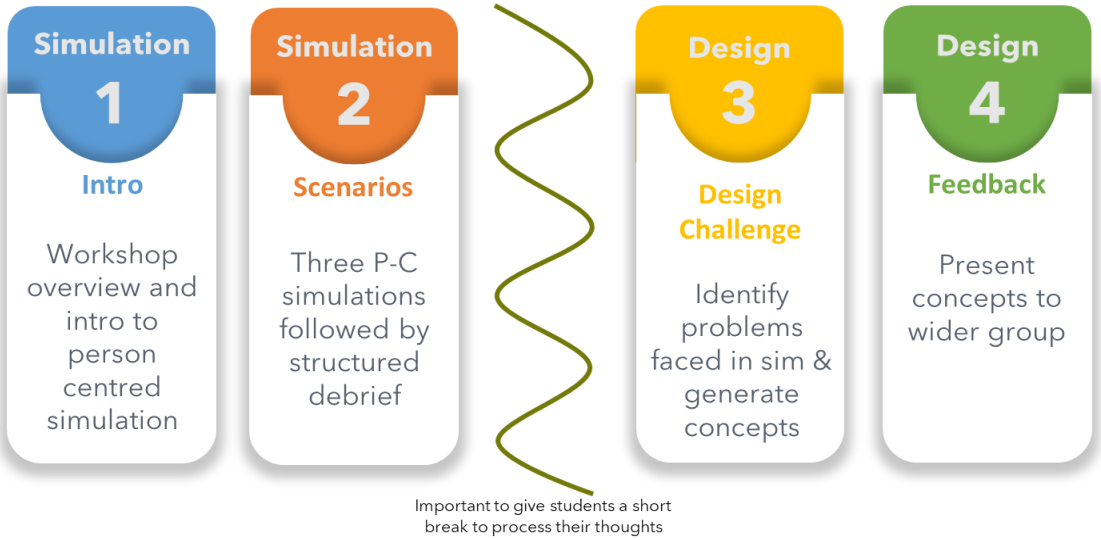

Figure 1. Person centred ageing simulation workshop format

Students were welcomed to InterSim, introduced to the format for the workshop and the concept of person-centred simulation. Time was dedicated for questions and to develop a safe participatory environment. Following this they were split into three groups. Each group had two facilitators (a GP and engineering demonstrator), and each group was given a different scenario.

1. Getting ready for the day
2. Going to meet a friend for coffee
3. Going shopping

Using GERT ageing suits and other devices, students carried out a series of small day-to-day tasks based on their given scenario. Following a structured and evidence based debrief (Bajaj *et al.,* 2017), each group had to isolate a specific challenge and use their skills as engineers to come up with design concepts to solve that problem. They had to consider how they could enhance the lives of those living with certain disabilities based on the activities they completed. Once concepts had been finalised, the groups reunited and pitched their product ideas to each other. To close the workshop the students shared their thoughts on the experience while discussing their responsibility as engineers and the importance of having empathy when designing for *all*. Students completed pre- and post-workshop perspective and exploration

questionnaires. The statements were adapted from empathy questionnaires, with the aim of capturing any change following the workshop. All students indicated on a scale from one to five how strongly they agreed with / how true the statement was / how well it described them (five being strongly agree/ very true / very well). Students also provided general feedback on the overall workshop.

Equipment & scenario environment

GERonTologic simulator (GERT) ageing suits and tremor simulation gloves were purchased from Product + Project, Wolfgang Moll (Germany). The suits provided age related impairments such as opacity of the eye lens and narrowing of the visual field, high frequency hearing loss, joint stiffness, loss of strength, reduced grip ability and reduced coordination. The suits were given to the groups and additional low-cost items such as googles, gloves, splints, patches, slings, and tape were used.

Having a mix of equipment types, i.e., equipment specially designed for this type of activity (GERT suits) and simple inexpensive pieces that are readily available provide the opportunity to expand the kit, allowing more students to experience an element of the simulation. Simulations can be achieved quite easily with everyday products for example, lab googles smeared with Vaseline were used to provide a visual impairment like cataracts. Wrist weights and taping the fingers provided an example of arthritis and problems with dexterity.

Each scenario was carefully considered and additional equipment was obtained were necessary.

1. Getting ready for the day

Using the Home-from-Home suite in InterSim, the room was set up to replicate a small studio flat, with a bed and kitchen facilities. This scenario included getting out of bed, getting dressed, making breakfast and taking medication. The medical condition for the scenario was, *the individual has left-sided weakness (hemiparesis) along with visual and hearing impairments.* Additional equipment included oversized clothing, utensils and food for making breakfast, and a basic pill box with medication (sweets) were provided.

2. Going to meet a friend for coffee

This scenario involved the group members leaving InterSim and going to the coffee shop within the medical building to purchase a hot drink and consume it on the premises. Due to ageing *the individual has problems with their right knee and ankle, arthritis in their hands and some visual/hearing impairments*.

3. Going shopping

This scenario involved the group members leaving InterSim with shopping bags, making their way to the carpark and getting into a car. *The individual has osteoarthritis. They have some minor visual and hearing impairments but are still able to drive.* Additional equipment included Zimmer frame, walking stick, shopping bags with heavy objects.

OBSERVATIONS AND OUTCOMES

In advance of the workshop students were provided with general information on InterSim, that they would be participating in an active workshop utilising the InterSim facilities, working with

medical professionals and using their skills as engineers. Therefore, it was particularly important at the start of the workshop to dedicate time to introducing the concept of person centred simulation and how they would be directly involved in these simulations. A concerted effort was made to create a safe participatory environment. It was equally important to give the students a short break after the simulation activities so they could gather their thoughts before participating in the debrief which explored their observations and feelings.

Figure 2. Images from simulations

Two participants acknowledged the relief they felt at being able to remove the equipment at the end of the simulation. While these tools provide short exposure to certain conditions, the impairment simulation cannot convey the true reality of living with such conditions, which the students recognised.

While pushing students out of their comfort zone during the simulations, this workshop also gave students the opportunity to apply their critical thinking skills as engineers as they had to identify a problem and implement an appropriate design solution to meet the needs of the individual in the scenario. Examples of design solutions generated by the students include scenario one: automatic medication dispenser, scenario two: shoe with sensors to prevent trips, scenario three: foldable walking frame with attachments for shopping bags. The primary focus was designing for the individual within their scenario however when developing their concepts it was found students didn't just consider one individual but incorporated features that would enable a variety of users to successfully use the product.

Three students (from separate groups) did not want to wear simulation equipment, due to personal reasons not disclosed, but they still participated with their group. Participation was not compulsory and it was anticipated that there may be students who may not want to undertake the simulation. Therefore, it was important there was an alternative element within the simulation to allow all students to engage. These students were given the role of 'observers. They observed the challenges faced by the individuals in simulation activities. This added a different dimension to the debrief and design section of the workshop, while giving those students the opportunity to actively participate with their group.

It is important to consider the finer details of scenarios and the environments used. For example, in scenario one the bed was pushed against the wall, meaning the individual had to get out using their left side, however this was the side of their body impacted by their condition. In scenario two students had reduced dexterity and were given cash instead of a bank card to

purchase their drinks. In scenario three the Zimmer frame was non-folding, the shopping bags had awkward handles and bulky items inserted.

Student Feedback

In an attempt to capture if their empathy towards design had changed over the course of the workshop students were asked to re-take the perspective and exploration questionnaire (Table 1) they had completed at the start of the workshop.

Evidence of a positive change was noted, however, to truly evaluate a change in empathy, students would need to be tracked for a longer period and evaluations captured from various aspects of their work.

Table 1. Pre- and Post-Workshop Perspective and Exploration Questionnaire Results

		n = 27		
	Statements	**% ↑[1]**	**=[2]**	**% ↓[3]**
1	I am confident in my ability to connect concepts and ideas that appear at first glance, to be unconnected.	33	63	4
2	I'm interested in experimenting in order to find new ideas.	26	59	15
3	Before criticising somebody, I try to imagine how I would feel if I were in their place.	59	41	0
4	I'm interested in giving a pitch or presentation to a panel about a new product or idea.	81	19	0
5	I have concerned feelings for people less fortunate than me.	37	63	0
6	If I'm sure I'm right about something, I don't waste much time listening to other people's arguments.	22	48	30
7	I am confident in my ability to generate new ideas by observing the world.	44	41	15
8	I sometimes try to understand others by imagining how things look from their perspective.	55	41	4
9	I am interested in finding resources to bring new ideas to life.	41	55	4
10	I get a strong urge to help when I see someone who is upset.	37	7	56
11	I am confident to experiment in a way to understand how things work.	33	37	30
12	I'm interested in developing plans and schedules to implement new ideas.	37	33	30
13	I sometimes find it difficult to see things from the other persons point of view.	26	33	41
14	I consider everyone's needs when it comes to designing.	59	37	4
15	I am confident in my ability to lead a team to challenge change in product development.	34	67	0
16	When I see someone being taken advantage of, I feel protective towards them.	45	55	0
17	If I see someone struggling, I am always willing to help them.	34	7	59

*__Results Key__: 1. Percentage of students whose score increased between pre- and post-workshop questionnaire, 2. Percentage of students whose score for statement remained the same, 3. Percentage of students whose score for statement decreased.

Overall, the student feedback was very positive. Key themes that came out of the workshop were, it was *interactive, enlightening, eye-opening and enjoyable*. Students enjoyed the small group format as it was '*conducive to getting involved'* and allowed for *'bouncing ideas off one another and coming towards a solution'.* One student noted that *'coming up with a new concept related to what you've done that day, helps the design process feel more grounded in reality'.*

Students stated that the simulation activities were "*good to experience*, and that it was '*eye-opening to see the difficulties people with these impairments go through on a daily basis*'. When asked how the use of ageing simulation has influenced their outlook/approach to engineering design, students said it '*really helped me think more empathetically, to take into account the needs of all types of people*', '*it has given me a fresh perspective on design, and how an optimal design can work for everyone'* and participating in the simulations '*allowed me to encounter the problems first hand rather than trying to imagine what they may be'*. Several students recommended that '*more workshops like this should be implemented for all students'*. In the final round-up, one student stated that this workshop made them think about the product they were developing as part of their final year project and how they needed to reconsider some of the features to make it more inclusive.

In terms of recommendations, the students would have liked more time to experience other simulations outside their group. While this would be ideal, it is difficult to achieve within the timeframe, and the format of the workshop would have to change. Five students suggested that it would be beneficial to experience this format of workshop earlier in their degree. However, 100% of those who completed the feedback survey (n=27) stated they enjoyed the design challenge, were very satisfied with the delivery of the workshop, and would recommend the workshop to other students.

CONCLUSIONS

This exciting inter-disciplinary, cross-faculty person-centric initiative provided a unique, innovative experience for final year mechanical and product design engineering students. Students got to briefly experience the reality of living with physical impairments, while in turn utilising their skills as engineers to develop solutions for the challenges faced within the scenarios. This also provided the opportunity for students to become more aware of the importance of empathy in the design process. Overall, the workshop has proven to be a valuable addition to the module. The format lends itself to several scenarios and could be adapted to suit other engineering disciplines.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Queen's University Belfast Innovation in Teaching Fund from which they received funding to purchase equipment for the workshop.

REFERENCES

Bajaj K, Meguerdichian M, Thoma B, Huang S, Eppich W, Cheng A. (2018) *The PEARLS Healthcare Debriefing Tool*. Academic Medicine, 93(2), p336 | DOI: 10.1097/ ACM.0000000000002035

Karvelytė M, Rogers J, Gormley GJ. (2021) *Walking in the shoes of our patients' a scoping review of healthcare professionals learning from the simulation of patient illness experiences*. Advances in Simulation. 4;6(1). 43. https://doi.org/10.1186/s41077-021-00194-

Singh A, Ferry D, Balasubramanian S. (2019) *Efficacy of Clinical Simulation-Based Training in Biomedical Engineering Education*. J Biomech Eng. 1;141(12):121011–121011-7. doi: 10.1115/1.4045343. PMID: 31660578; PMCID: PMC7104742.

Sochacka N, Walther J, Miller S, (no date) *Fostering Empathy in Engineering Education* Scientia Global,https://www.scientia.global/wpcontent/uploads/Sochacka_Walther_Miller/Sochacka_Walther_Miller.pdf

Vage A, Spence A, Hamilton P, Gormley G. Spoonful of Sugar (2022) *A Case for Stress-reduction Interventions in Medical Simulation.* The International Journal of Healthcare Simulation - Advances in Theory & Practice. Sep 2.

BIOGRAPHICAL INFORMATION

Kathryn Fee is Director of Education (PGT) and a Lecturer (Education) in the School of Mechanical and Aerospace Engineering, Queen's University Belfast (QUB). Kathryn's scholarship bridges engineering education, ethics, leadership and employability. Kathryn strives to advance pedagogical strategies that prepare engineers to navigate complex societal challenges with integrity, empathy, and purpose.

Aislinn McAleenan is a Research Fellow in the School of Mechanical and Aerospace Engineering at Queen's University Belfast and a member of the Smart Manufacturing & Robotics Research Group. She holds a Master's degree in Mechanical Engineering and a PhD focused on the design, development, prototyping, and control of a patented 3R1T parallel robot for minimally invasive eye surgery applications.

Matthew Cairns is a PhD student based in The School of Mechanical and Aerospace Engineering at Queen's University Belfast. A Mechanical Engineering graduate from the school and the first Engineering Education PhD student at QUB, his work is focused on final year projects, and the opportunities and challenges that self-proposed projects can provide.

Gerard Gormley is a General Practitioner and academic in the Centre for Medical Education (CME), Queen's University Belfast. As a Professor in Simulation and Clinical Skills, he leads the Clinical Skills Education Centre (CSEC) unit in the Medical School. He strives for excellence in providing the best learning experience for student doctors in their clinical skills training.

Corresponding author

Dr Kathryn Fee
School of Mechanical & Aerospace Engineering
Queen's University Belfast
Ashby Builiding, 125 Stranmillis Rd,
Belfast, N. Ireland
k.fee@qub.ac.uk