Using Biomechanics to Inform Student Learning about Chair Design

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Introduction

The chair is an item of furniture that is encountered in all aspects of human life and is taken for granted. Prolonged chair use has been associated with increased musculoskeletal pain and disability, especially in office workers [1]. The science of ergonomics is used to optimise chair design. Ergonomics (or human factors) is the scientific discipline concerned with interactions among humans and other elements of a system in carrying out a purposeful activity [2]. Evidence that ergonomic interventions improve chair comfort and function is controversial [3]. Rising from a chair (the sit-to-stand movement – STS) is needed in order to walk and function independently. Inability to perform this task can lead to impairment of activities of daily living and loss of independence, especially in the elderly. Several aspects of chair design affect the STS movement. A recent review has suggested that in order to evaluate STS effectively, chair type, chair height, foot positioning and use of armrests should be analysed [4]. During the process of chair design for domestic or occupational use, analysis of the STS movement is essential.

Musculoskeletal disorders account for half of all chronic disease among adults aged > 65 years, and demographic changes mean that there will be 1555 million adults aged > 65 years by 2050. The world health organization states that osteoarthritis is set to be the 4th highest impact disease in women and 8th among men worldwide. Musculoskeletal problems cause more disability among the general population than either heart disease or cancer. Back pain, and neck and upper limb (shoulder) pain, are the leading causes of sickness absence among working-aged adults. Musculoskeletal disability affects chair use in several ways because of joint pain, stiffness and muscle weakness. This affects not only chair use but also how the affected person interacts with the environment around the chair.

The discipline of biomechanics, defined as:

"…. the science concerned with the internal and external forces acting on the human body and the effects produced by these forces" [5] has made great strides (using advances in computer technology) in understanding human movement in health and disease. The aims of this multidisciplinary project are to develop innovative strategies in learning and teaching about chair design, and to provide experience in digital manipulation of designed objects.

Stage1
Introduction to the Biomechanics laboratory Eastbourne

A group of year 2 design students were invited to attend the biomechanics research lab based at the Eastbourne campus. The aims of this session

were to familiarise both the students and the investigators to working in a multidisciplinary environment, and to begin to work out a language that would be understood by all and facilitate the work for the rest of the session. Students reported that the lab was a foreign environment not only visually, but also in smell and feel. It felt "scientific and medical". Students were shown the specialised equipment that was used to capture human movement. The students were asked to think about how humans sat down and rose from chairs, so deconstructing the sit-to stand-movement using a problem- and inquiry-based approach, rather than a didactic lecture. Students had not really appreciated the complexity and number of muscles and senses required to carry out this seemingly simple function. A full-size skeleton was used to reinforce in a visual manner how the skeleton was constructed and used in the sit-to-stand movement.

The next stage of the session involved using the "force plate". This machine calculates numerically and visually the forces and movements in 3 dimensions generated when rising from a chair. A number of chairs of different designs were put on the force plate and the students performed the sit-to stand movement. The impact of chair design on this movement was discussed qualitatively and also quantitatively using the graph from the force plate. Students then performed the same movements with simulated musculoskeletal disabilities e.g. rising from the chair using only one leg, or without using the arms. The force plate graphs were seen for the same chair and individual with and without the disability. The workshop was filmed.

Analysis of reflective documents written after this session highlighted the following themes:

- Students did not appreciate the impact of musculoskeletal disability on simple everyday movements
- Initial fear of working in a "scientific" environment

Later, appreciation of similarities in working between designers and scientists

Stage2
Meeting patients and medical students

This stage started in March 2007 after the appointment of our research assistant Tom Ainsworth. Semi-structured interviews with carried out with year 2 design students to understand their perceptions of art/science collaboration, both barriers and opportunities. Analysis of the qualitative data highlighted several themes:

- Enthusiasm for art/science collaboration in their work
- Institutional barriers to interdisciplinary working: art and science students work on separate campuses with little or no interaction. Tutors/supervisors unaware of contacts for facilitating interdisciplinary working
- Students very aware of the importance of science in design, although design students did not perceive themselves to be confident in understanding scientific language and literature

These themes were further explored in 2 further workshops. In the first workshop, design students met a patient with rheumatoid arthritis in the biomechanics laboratory. The students were able to ask the patient about the impact of chair and furniture design on his ability to carry out everyday tasks, and investigated how the patient used chairs of different designs using the sit-to-stand movement on the force plate and the graphic readings arising from the plate. Students used this qualitative and quantitative data to further understand the balance between aesthetic, tactile and functional qualities of chairs in general and in people with musculoskeletal disability.

The second interdisciplinary workshop took place with medical and craft/design students and the same patient with rheumatoid arthritis. The initial phase of this workshop involved the medical and design students to talk to eachother, using their descriptions of the equipment in the biomechanics lab and their courses of study, in order to overcome barriers and develop a common language for the session. The design students brought stools that they had manufactured. The students were asked to explain the thinking behind the design of the stool, taking into account both aesthetic and functional aspects. The medical students and patient also discussed each stool, and performed the sit-to-stand movement was using the force plate. The force plate graphs were studied and interpreted by the patient and students, followed by a further discussion around the areas of aesthetics and function.

Themes arising from the discussion were:

- Design students had no real awareness of the impact of musculoskeletal disability on chair and stool design
- Medical and design student interactions were initially cautious, but after sharing their experiences, they became much more comfortable with eachother
- Creativity and critical appraisal: Medical students initial perception that design students did not use an evidence base or critical appraisal in their work, and that medical students are not creative like art/design students. After discussion with their peers and understanding the use of language in different disciplines, both sets of students realised that they had much more in common than they thought, both using an evidence base to inform their work, and medical students appreciating that they were creative, for example when undertaking their research projects.
- An enthusiasm for medical and design students to work together in the clinical environment to further facilitate interdisciplinary working and development of a shared language.

Pedagogy

Students attending the workshop have had multiple pedagogic approaches to their learning. The experience of the workshops, together with the time for reflection, allows students to use the principles learned in new situations, allowing the principles to be tested and refined with further reflection [6]. Interestingly, design students became aware that this was

a concept important in both art and science disciplines as the workshop progressed.
Problem-based learning (eg what is the impact of musculoskeletal disability on the sit-to stand movement?) allowed the students to work together to define the problem and create strategies to obtain the information required to solve the problem. The problem needed to be solved in both theoretical and practical ways, so encouraging action-based learning. Peer-learning was also used in this context. Peer learning has been shown in small group work to encourage positive learning approaches such as deep learning and intrinsic motivation [7].

This project will also highlight the utility of interprofessional education. (IPE), which has been defined as "occasions where 2 or more professions/disciplines learn from and about each other to improve collaboration [8]. The advantages of this method are several: it is interactive, reflective and experiential, activities challenge preconceptions and stereotypes, and learning outcomes include further collaboration between disciplines [9].

One example of academic development where IPE is envisaged as an integral aspect of programme design is the newly validated MDes/MFA Thre Dimensional Design and Materials Practice programme at the University of Brighton Faculty of Arts. In this 4-year model, a 30-Credit option unit at level 3 or level 4 is built around IPE as a platform for research reaching a wider professional or community environment. An extended professional Practice programme also reflects examples or short case studies of such inter-disciplinary working.

Conclusion

This innovative project has shown that there are few personal barriers to interdisciplinary art/science collaborations. Student experience and reflection has led to long-term changes in attitude to design with respect to appreciation of the impact of musculoskeletal disability. The next phase of this project will involve further design/medicine collaboration in order to understand the impact of design on health and wellbeing of staff and patients in the clinical environment. This will hopefully lead to the development of a model for interdisciplinary working.

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