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Enabled Design: Engaging First Year Engineers in Inclusive Design

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BACKGROUND
Design practice has a significant role to play in inclusive design (Imrie and Hall, 2001). Engineers need to be conscious of the impacts of their design decisions and how these can limit or exclude certain user groups from a technology (Clarkson et al 2003). By changing their design they can enable use and access for a larger number of people in a more equitable way (Coleman, 2005). The construction of a 1/10th scale model of a communal toilet block was used to introduce this concept to first year engineering students to assist in understanding the impact of their work on users and social inclusion.

PURPOSE
What was the impact of a hands-on scale-model build activity on first year engineering students' view of inclusive design?

DESIGN/METHOD
The focus of the activity was a 2-hour workshop session. Small groups (4-5 students) identified their perceived requirements for multiple user groups such as people who have a visual impairment or physical disability. They then constructed a model of the toilet with facilitators challenging students' designs and underlying assumptions throughout the process. A survey was administered upon completion of the activity to around half the entire class of 210 first year students to gather details on students' understanding and learning from the activity, and from which to draw implications and conclusions.

RESULTS
The activity led almost all students to indicate they had a better understanding of the requirements of inclusive design although there was significant variation in students' understanding of what this term meant. Almost half the students indicated the activity also changed their view of engineering and design. Improvements to the structure of the workshop and support material and access to a wheelchair for students to use were identified as potential improvements.

CONCLUSIONS
The use of a practical hands-on build activity enabled the complex topic of inclusive design, and indeed engineering design in general, to be introduced in an approachable and enjoyable manner for engineering students. There was variation in students' understanding of the term with many focused on the design and user requirements aspects rather than the social inclusion and access outcomes. Further discussion of social inclusion from design and service-learning style programs are required to build on such introductions to allow the students' views to develop further.

KEYWORDS
Enabled Design, Inclusive Design, Social Inclusion

Introduction

The role and importance of design in enabling or denying access to a technology and its benefits is clear and well documented (such as Imrie and Hall, 2001, Clarkson et al, 2003, Coleman, 2005 and Gilson and DePoy, 2011). Even elements seemingly as simple as introducing a step to a doorway creates a barrier that can exclude people from not only the physical space beyond but the services and social interactions within. Users who do not have the capability to meet the demands of a product, design or technology are subject to *design exclusion* and hence social isolation and injustice (Clarkson, 2003). A more inclusive form of design must be adopted by those involved with all levels of design, including engineers, to ensure unnecessary barriers are not created.

Design exclusion can affect people with disabilities and groups including the elderly and the very young, pregnant woman and people with assistive devices such as walking frames and sticks, crutches and prams. Worldwide it is estimated there are one billion people living with a disability (World Health Organisation, 2011, p29). In developing contexts, social exclusion and isolation is often greater given fewer medical services and discrimination associated with disabilities (World Health Organisation, 2011, Thomas, 2009). In developed countries such as Australia and the UK, an aging population is a significant driver for technology and products that can be used by a larger percentage of the population (Coleman, 2005).

One approach for engineers is to practice *human-centred design* (HCD) where users and clients are placed at the centre of the engineering design process rather than a technology first approach (Cardella et al 2012). Extending this concept, *inclusive design*, also known as *universal design* in the US and *design for all* in Europe, has become an important approach within design disciplines including architecture, industrial design and engineering (Clarkson, 2005). This approach utilises a deeper understanding of user groups and diversity in order to provide products and designs that satisfy the needs of a greater number of people (Engineering Design Centre, 2012).

Inclusive design is reinforced in the social model of disability which places the cause of an individual’s disability in the society and context around them, rather than focusing on the individual (Oliver, 1990). This model became popular in the 1980’s and 90’s as a response to the medical model of the time which focused on a medical approach centred on an individual’s disability (Pfeiffer, 2002). Although there is discussion around the current relevance and appropriateness of the social model (Shakespeare and Watson, 2002), many, if not all, of the current models recognise the challenges and inappropriateness of external social barriers to providing access and inclusion for people with disabilities and others (Pfeiffer, 2002). This again highlights the role and importance of design in these models and approaches.

Inclusive and human-centred design are now often incorporated into engineering programs through activities including service learning (Cardella et al, 2012) and case studies (Riley, 2008). Having appropriate and effective learning experiences for students to be introduced to and understand these concepts and ideas and recognise their role within design exclusion can be challenging, especially given the typical demographic of the engineering student cohort where minority groups such as those impacted by design exclusion are under-represented (Pierrakos et al, 2009).

This paper outlines the use of practical kit based learning activity to introduce the concept of inclusive design to first year engineering students. The activity and its design and development are outlined first, followed by its implementation in a first year introductory engineering course. Results and evaluation from student surveys are provided along with a discussion on impacts and suggestions for future improvements to the activity and its use in other applications.

Activity Kit Overview

In order to introduce the concept of inclusive design to first year engineering students, an appropriate learning experience was required given the students' backgrounds, learning preferences and course constraints. A model kit of a single toilet block had been designed by the second author based on his personal experience of design exclusion and accessibility. This was used in an inclusive development workshop in Timor Leste, constructed using local skills and materials. This kit worked well and given its practical nature was deemed a relevant idea to trial.

The initial kit was redesigned and manufactured to be used within a workshop or group activity. This involved a redesign of the model to 1/10th scale and provide for more flexibility of construction and inclusions. Personal experience of the first author who has spent significant time on crutches and also recently became a parent was incorporated.

The redesigned kits have pieces to build a stand alone toilet block including the structure (walls, floor, roof, door), access (ramp, platform), fixtures (hand-rails, door handles), the toilet (different types of squat toilets) and accessibility aids (chairs, commodes). See Figure 1 for constructed kits. With each kit are scale model figures representing nine different user groups, including two different wheelchair users, users with crutches and walking sticks, a pregnant women, a person with a pram and a child.

In keeping with positive language (as discussed in Nocalla, 2008) the kits are called *Enabled Design* kits. For example, rather than a *disabled* parking, where the parking spot is not actually disabled, it can be called *enabled* as it is available and useable for a larger number of users. The terms inclusive design and enabled design are used interchangeable within this discussion.

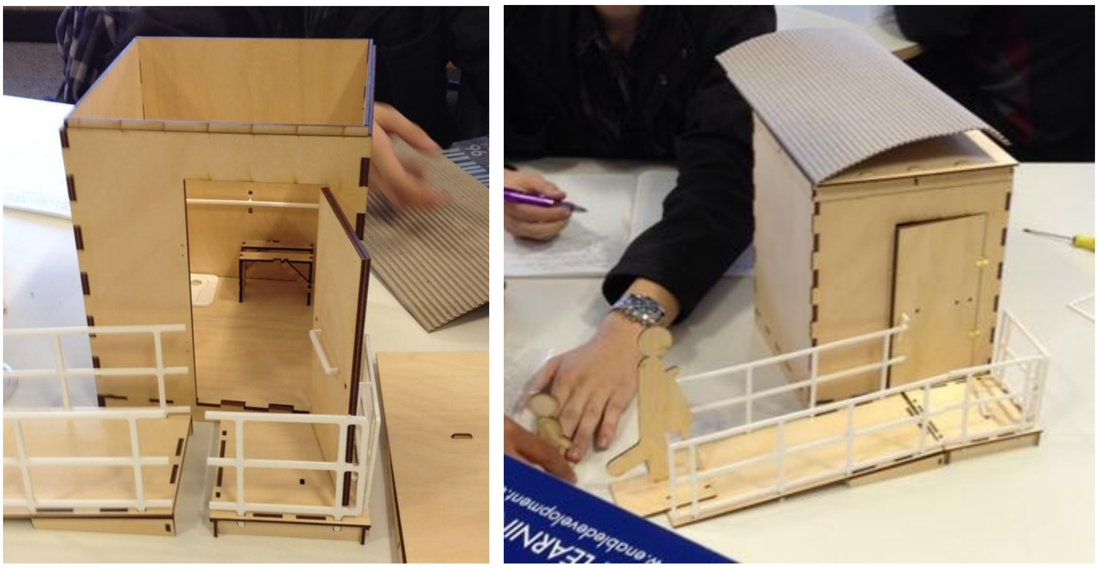

Figure 1: Kits in use during the workshop, being tested on the right with a user with crutches

The finished kits are designed to be used in a facilitated workshop activity, typically of two hours duration. The next section will describe how the kits were implemented within an undergraduate engineering course.

Implementation and Use

The kits were used as the base for introducing the concept of inclusive design within a first semester, first year introductory engineering course. They were used in week 7 of a 13 week semester with a focus on *user requirements*. A lecture at the start of the week introduced developing design criteria and user requirements, including the use of ‘old person suits’ used by young Nissan engineers to simulate a specific user group (World Car Fans, 2008).

A training session was held for the six course tutors by the second author where the tutors undertook construction of the kits themselves. At that session, one of the tutors was on crutches from a sporting injury while another regularly uses a walking stick and these two could share their personal experiences.

The activity was then delivered over a week to all students via the 10 regular practical sessions, typically with 20 students per group. The session started by looking at developing a set of design criteria for a chair, including simulation exercises with a leg brace and crutches and vision-impaired goggles (to reduce visibility) which took about 15-20mins. The class was then divided into groups of 4 or 5 and each given a kit. Groups had to construct a toilet block for 2 or 3 specific users groups (see Figure 1). The tutors acted as facilitators, questioning groups’ designs and decisions, and their underlying assumptions. Students hence had to see themselves as the users’ to understand their needs and abilities in being able to access and use the toilet block and see the impacts of design decisions in creating exclusion. After about an hour, a class discussion and reflection was held on the challenges faced and designs developed.

The workshop replaced a one-hour tutorial on user requirements given the previous year in which simulation aids only were used to explore the concepts of user groups, requirements and capabilities. Feedback from course tutors had highlighted limitations around this approach although the use of props and simulations had worked well and provided an additional element of student interaction.

Evaluation and Results

To provide an evaluation of the activity and student views on enabled design resulting from it, and to give a base-line for future years and activities, a written anonymous survey was administered upon completion of the workshop. It was used in every second workshop, five of the ten workshops, giving a potential total of 104 respondents of a class size of 210. This also covered five of the six members of the teaching team. Not every student answered every question and as the questions were open ended, students could state multiple responses (Table 1 shows the response rate for each question). The questions asked were:

1/ What does the term *enabled design* mean to you?

2/ Did this activity help you understand enabled design requirements?

3/ What role, if any, do you think engineers have in making their designs and technology enabled?

4/ Has your view of the role of engineering and design changed as a result of the prac exercise?

Table 1: Number of responses per question

Question	Responses	% of Potential Total
1	91	88%
2	104	100%
3	100	96%
4	103	99%

Responses for questions 1 and 3 were coded by the first author to identify groups of responses. Themes were then developed based on the groups and responses re-coded into these themes and reviewed by the second author. Pre-defined themes or categories were not used. Responses for questions 2 and 4 were generally one or two word answers, typically yes or no, and hence these were analysed quantitatively and the frequency of responses determined. Results from all questions are shown in Tables 2 to 5.

Table 2: Responses to question 2 on exit survey, *did this activity help you understand enabled design requirements?*

Response	Respondents	% of Total
Yes	88	85%
No	6	6%
A Little / Somewhat	10	9%

As a general response to the activity helping to understand enabled design, Table 2 shows that only 6% of participants did not find the activity in at least in some way helpful to their understanding. However as shown in Table 3 six themes of enabled design were identified from student responses of which only one, *Accessibility*, started to capture the impacts of enabled design around access and inclusion. Other themes were focused on capturing user needs from various groups and incorporating them into the design process. These themes placed the emphasis on users needs within the engineering process rather than the influence of the actual end result on social inclusion and accessibility.

Table 3: Themes identified from question 1 on exit survey, *what does* enabled design *mean to you?*

Theme	Description
Meet Needs	Design must meet specific needs or user requirements
Part of Process	Is related to completing the design process or incorporated into project work
Flexible Design	Design must be able to cater for different needs, requirements or abilities
Include PWD	Design must include or be designed for people with a disability (PWD)
Design for All	Must design for everyone and include the needs of all
Accessibility	Designs must be accessible and provide full access for users

In terms of the responsibilities engineers have in making a design or technology enabled, a wide range of responses were identified as listed in Table 4. The majority of responses saw the role relating to the final design and ensuring it has due consideration for users. Only a small number of themes identified an external role, such as a legal or ethical one, or a broader role in providing inclusion and a social responsibility. Related to the responses in Table 4, ethics and professional responsibility had not been covered as topic in the course.

Table 4: Themes identified from question 3 on exit survey, *what role, if any, do you think engineers have in making their designs and technology enabled?*

Theme	Description
In Design	A role in creating a design that meets user needs or requirements
Consider Users	To ensure a design or technology can be used by all, or all users considered in design outcome
Problem Solving	Solve problems faced by users
Providing Accessibility	Design or technology must be accessible to all
Responsibility	An un-specified responsibility, but one exists
Setting Criteria	A role in setting the design criteria or user requirements
Helping People	Developing a design to help people
Part of Process	A role across the entire design or engineering process, where customer needs are the first step
Client Needs	A responsibility to the client or customer, to design what is required
Legal Requirement	A legal responsibility
Social Responsibility	A broader responsibility to society
Profit Motive	A role to generate profit, by increasing the size of potential customer base
Ethical Responsibility	An ethical responsibility

From the last question it was found that almost half of the students changed their view of engineering and design due to the activity (Table 5) although how was typically not stated and not enough responses gathered to provide further analysis.

Table 5: Responses to question 4 on exit survey, *has your view of the role of engineering and design changed as a result of the prac exercise?*

Response	Respondents	% of Total
Yes	47	46%
No	28	27%
A Little / Somewhat	13	13%
Reinforced View	15	15%

Discussion and Future Work

Implications and Impacts

In response to the purpose of the activity, it introduced a range of understandings of inclusive and enabled design and provided a broader impact in changing views of engineering and design. From the students' perspective the activity has helped to understand the idea of enabled design (as seen in Table 2). However, from Tables 3 and 4 the understanding of these concepts and their application is broad, reflecting the students' past experience before university and within the course where the focus had been on the engineering design process and design criteria more than the external influences on engineering. The activity also received more positive feedback from students and course tutors due to the build element than the previous years' activity which was based around simulation aids only.

The influence of the activity was seen in some other elements by the end of the course. The EWB Challenge Design Project is used as a group project within the course and from the 44 teams in the course two developed solutions involving redesigned toilet systems. Both of these designs had access ramps rather than steps or stairs. In an end of the semester exit survey, 4% of the class nominated this activity among their favourite learning experiences for the entire course, making it the tenth most popular out of 22 separate experiences identified by student responses.

Response themes identified will help to shape how the concept of inclusive design will be introduced and reinforced across different year levels. Considering inclusive design from an ethical and professional responsibility point of view will also need to be highlighted given the results in Tables 3 and 4. Inclusive design was seen predominantly as part of the a engineering design process with the focus on the engineering rather than around users' abilities and inclusion during the design process and as a end result. A case study of inclusive design will be incorporated into lectures post the workshop activity to reinforce some concepts and promote further discussion.

From the last question (Table 5) the activity changed the views of engineering in some way for more than half the students, suggesting the activity has broader applications, although this requires further study to understand why. The activity could be used to provide an introduction to general engineering concepts including teamwork, design, collaboration and constraints and hence could be used in other areas to support learning around those concepts or as a team building exercise at the start of a group project or course. By selecting a specific user group the kits could also be used as an exercise to help introduce HCD.

The kits could be used as an exercise in preparing students for community engagement and service learning as highlighted in Oakes (2012) and Terpenny (2006) and in as programs as ROXIE (Real Outreach eXperiences In Engineering, Goff, 2010). Cardella et al (2012) provide a description of a number of different pedagogies for introducing HCD which are also relevant to inclusive design. Externally-supported programs are required to reinforce and fully experience the concept of inclusive design introduced through the activity.

Improvements and Additions

From feedback from students, surveys and the course teaching team, a number of improvements and additions have been identified for the use of the kits in future years. The session will focus solely on the activity around the kit, the discussion at the start around criteria for a chair will not be used. This was seen, particularly by the tutors, as an unnecessary introduction and in some cases even a distraction. Key points from this part of the workshop, particularly using the simulation aids, will be integrated into the rest of the activity. In addition to the existing simulation aids, a wheelchair will be made available to students to have first-hand experience of their use. The Engineering Design Centre (2012) provides additional simulation activities that will be evaluated for possible incorporation into the workshop to help students experience different views.

As an extension to the discussion following the build component the relationship to standards will be raised. How standards are created, their role and stakeholders involved will form the focus of this discussion. Information from additional resources (including Werner, 1998, Cambridge Engineering Design Centre, 2005 and Design Council, 2008,) will also be incorporated around the activity to provide examples and case studies of inclusive design.

Conclusion

A practical activity involving the design and use of a 1/10th scale model of a single toilet block with a variety of user groups was used to introduce the concept of inclusive and enabled design to first year engineering students. From a survey taken at the end of a two-hour practical activity using the kits it was found that over 90% of students indicated the activity had at least somewhat assisted in their understanding of enabled design. Looking further at student responses there was variation in students' understanding and view of this concept with most focused on the design and user needs elements rather than accessibility or inclusion. As an additional outcome, almost half the students stated the activity changed their view of engineering and design. Case studies and service-learning programs or design projects are required by students to fully experience and apply the concepts of enabled and inclusive design in more depth.

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