Engaging prospective students with Mechanical Engineering

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SESSION C4: The role and impact of engineers and the engineering profession in the wider community

CONTEXT
With more Australian engineering degrees adopting a common first year model, there is significant opportunity for specialisations to promote themselves to students in order to increase their enrolments. Against a backdrop of increased competition to attract students and adverse media attention on mechanical engineering with the collapse of the automotive manufacturing sector in Australia, the Mechanical and Aerospace Department from a Melbourne based university considered it imperative that a more concerted effort be made to promote mechanical engineering in the extra-curricular space. While the pedagogy of engagement within the context of the classroom is widely documented, few works focus on how these techniques translate to engaging students beyond their normal studies. Thus, recommendations from the literature on learning and engagement can be made to inform a generic activity design. However, the adaptation of these for enhancing student understanding of a specialisation of engineering in an engagement purpose is relatively uncharted territory.

PURPOSE
This research describes the design of a modular and multifaceted engagement activity, informed by literature on engagement pedagogy. Furthermore, the research details how this was applied to change preconceived notions of what mechanical engineering is, for a cohort of first year students prior to their engineering branch selection.

APPROACH
Recommendations from the literature on learning and engagement were researched and collated to form a generic set of engagement activity design requirements. These were used to develop a mechanical engineering engagement activity (MEEA). The activity task, inspired by Theo Jansen's walking machine "The Strandbeest", was designed to highlight various aspects of mechanical engineering, and draw links to existing unit learning outcomes in the degree. The MEEA was subsequently implemented and a mixed method approach to surveying participants was utilized.

RESULTS
An increase in the self-reported understanding and appreciation of the scope of the mechanical engineering discipline was seen for students who participated in the MEEA. Results indicate that there was an increased female interest and representation in the MEEA.

CONCLUSIONS
The implementation of the MEEA resulted in a greater understanding of the breadth and variety of careers available to mechanical engineering graduates. It can be suggested from this that scholarship of learning and teaching can be successfully applied in the engagement space.

KEYWORDS
engagement, first year, branch selection, discipline selection, common first year

Introduction

In 2015 a prominent Australian University changed the structure of its engineering degree significantly to incorporate all branches in a common degree structure. Previously, the aerospace, mechatronics and environmental engineering streams were standalone degrees. Consequently, there was more opportunity but also more competition to attract students to each specialisation. Similarly, the discipline stream units were merged into new design themed core units which encompassed elements of each branch.

Mechanical engineering is commonly associated with cars due to the likeness with mechanics. While classical and many modern mechanical engineering roles do involve cars, there is a whole host of opportunities which lie outside of this trope. By redefining mechanical engineering as involving the study, analysis and design of anything that moves or is subjected to forces or loads, it places emphasis on the broader context which mechanical engineers can exist in. This is particularly important for attracting a diverse group of students whose interests may fall outside of this stereotype and may be unaware of the broader roles of a mechanical engineer in society. Furthermore, engineering in itself is typically viewed as an overtly male dominated field (Smeding 2012, Ceci et al. 2007, Cheryan et al. 2015). While the numbers of males still outweigh those of their female counterparts, the number of females in engineering and mechanical engineering are slowly rising (Kaspura, 2015). This stereotype however is grounded in numbers. Engineers Australia documented the number of female engineering graduates as being 15.8% across all disciplines and 7.14% for the "mechanical and industrial engineering" group (Kaspura, 2015). At the university in question this trend is paralleled with approximately 22% female enrolment across all streams and approximately 14% in mechanical engineering (Phimphachanh 2016). These low numbers consequently feedback into themselves as it further perpetuates the misconception that women cannot or should not partake in engineering as reflected by the low rates.

Against a backdrop of adverse media attention on mechanical engineering with the collapse of the automotive manufacturing sector in Australia, it was considered imperative that a more concerted effort be made to promote mechanical engineering in the extra-curricular space. The Department of Mechanical and Aerospace Engineering (Dept. M+AE) chose to develop new engagement workshops to be primarily held during orientation week and in the lead up to branch selection. The Mechanical Engineering Engagement Activity (MEEA) was designed to initialize contact and dialogue between prospective first year students, the Dept. M+AE and current students. With a generic underpinning design stemming from scholarship of learning and teaching, it was intended that the MEEA would attract and engage students, particularly those undecided on a stream of choice. The MEEA aimed to improve students understanding of and familiarity with the mechanical engineering course and careers and to improve enrolment levels for the mechanical engineering stream, along with an increasing proportion of female students. Additionally, it was intended that after implementation at a university level the activity could be deployed wider into the high school engagement space to engage a broader cross section of the community with mechanical engineering and increase visibility of women in mechanical engineering.

Theoretical Perspective

Techniques to Attract Students to STEM

Fun activities have long been used to attract and engage students. In recent years, they have commonly been used as tools to attract students into STEM. They have the largest effect when activities break down complex mechanisms and systems into a simplified and easier to understand framework (Shernoff et al., 2003). It has been shown that hands on activities are the preferred method by high school students to be engaged with engineering (Little et al., 2009). Furthermore, it has been shown that students engage and are motivated

most when presented with a challenging problem to solve independently with appropriate support (Shernoff et al 2003). Voluntary student participation in engagement activities has also been positively correlated with improved academic outcomes (Wilson et al. 2014).

Specific Techniques to Engage Female Students

Colours and tones have gender associations in common society, with darker tones and blue hues being associated with males (Cunningham, 2011). Thus by including colours and tones not primarily associated with the male gender, it assists in positioning mechanical engineering as being a more inclusive discipline. Furthermore, it has been shown that female students in particular require strong female influences on career model off (Watt, 2016). Thus, by having a strong female influence in the demonstration and delivery of workshops, students will be more impartial to considering mechanical engineering as a stream of selection.

Method

Generic Engagement Activity Design

An ***active learning*** mode of delivery was selected as most appropriate as it has been shown to be one of the most engaging methods of content delivery for students (Prince et al., 2007; Anderson R et al., 2007; Prince, 2004; Taylor 2014; Shernoff et al., 2003). Tasks were ***inquiry based*** to facilitate ***critical thinking*** and ***problem-solving skill development*** (Shernoff et al., 2003; Prince et al., 2007). A wide range of ***connections*** or links ***with elements of the relevant degree*** were included (case based teaching; Prince et al., 2007). These links were drawn explicitly, by relating activities to specific units or areas of study, as well as signposting how particular skills are further developed over the course of the degree

Sample competency levels were shown to give students an idea of how their capabilities would be developed. ***Activity difficulty*** was set slightly above the expected level of competency (Shernoff et al., 2003). Where dependencies were identified between tasks, ***appropriate scaffolding*** was provided to allow for correct solutions to be implemented before transition to the next task. In this way, ***all groups were paced*** and were able to ***progress at a similar rate***.

A ***multifaceted and modular*** activity was selected, so that it could be deployed in a variety of different contexts. Simplicity in the execution of the activity was desired, such that it could be maintained and delivered by final year university students with ***minimal preparation or training***. To ***ensure program longevity***, a handover process was established. This included storing all designs and teaching materials such that they are permanently accessible.

A ***unique brand identity*** was carefully applied consistently in line with theories on gender neutrality in colour and branding. A ***relaxed, casual and inviting session ambiance*** was carefully cultivated through the use of music and the way the students and staff running the activity presented themselves and interacted with attendees (Gasiewski et al., 2012). Demonstrators were carefully selected, with a preference for people who were ***personable, welcoming and approachable*** so participants felt they were able to freely discuss any predicaments and questions with them (Gasiewski et al., 2012).

MEEA Activity Theme

A walking machine inspired by Theo Jansen's walking sculpture series "The Strandbeest" (Jansen, 2016) was designed using computer aided design (CAD) and manufactured primarily using laser cutting as seen in figure 1.

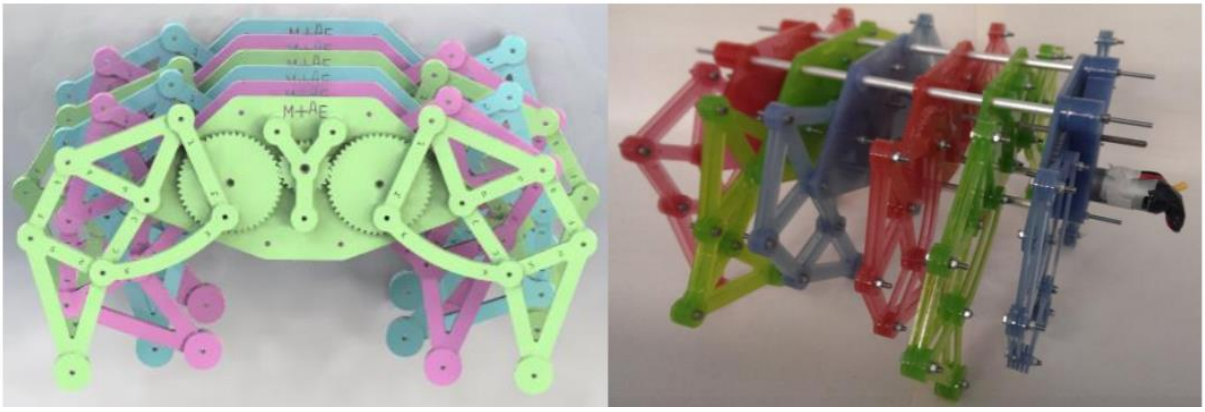

Figure 1: CAD of finalised walking machine design with single motor drive (at rear) showing the redesigned gear train (left) and image of completed walking machine assembly with dual drive capabilities (motors attached at each end).

The walking machine comprising six individual leg assemblies was designed such that it allowed for a range of tasks to be generated from its design. The outline of the leg section could be developed before structural integrity of the "stacked" arrangement explored. Each leg assembly was designed such that it could function independently from the complete assembly. The common "crankshaft" based driving method did not provide this capability, so the crank was replaced functionally with a redesigned gear train which could be driven by an Allen key or long hexagonal rod in the single and total assemblies respectively. Nyloc fasteners were used to prevent self-tightening or loosening of standard nuts due to torques generated during walking. DC gear-reduction motors were incorporated on both a single and dual drive basis with control boxes and mounts being designed and laser cut for each set up. The two-motor design allowed the device to walk forward, backwards and also turn.

MEEA Activity Details

A 3-hour MEEA was designed around the generic engagement activity guidelines described above. Pairs of students were tasked with discovering the correct leg mechanism assembly and stacked arrangement. Students were paced through this by giving solutions at each stage before progressing to the next stage. That is, they were given the correct leg mechanism before proceeding to determining the correct stacked arrangement of a single leg before proceeding to determining the double leg arrangement. After assembly and testing of their single leg set, six of the pairs of students worked together to determine the optimal phasing of the legs to allow successful operation of the walker.

In the session introduction and at each opportunity throughout the session's activity, elements were linked back to aspects of mechanical engineering and the mechanical engineering course at the university. For example, when discussing manufacturing methods of the activity's walking machine, 3D printing and laser cutting were discussed including their use on projects such as aerospike engines and 3D printed hands. Another example is when determining stacked arrangement structural integrity and design of structures to react shear, bending and torsional loads without breaking is discussed and linked to the Solid Mechanics unit in which these concepts are covered.

Generic marketing to attract students using images of the walking machine, a brief outline and the session details were used to attract students. A strong female leads and primarily female support demonstrators were utilized unbeknownst to students at the time of registration. A voluntary and anonymous paper survey of participating students was collected at the completion of the most recent workshop set with approval from the university's Human Research Ethics Committee (Project ID: 10581). This survey employed a mix method approach of non-Likert scale (Select from statement responses), two Likert scales (Very Poor/ Poor/ Average/ Very Good/ Excellent and Definitely Not/ Not Likely/ Likely/ Very Likely/ Extremely Likely) and open-ended questions (Text response).

Results and Discussion

The MEEA was initially implemented for first year engineering students. It has attracted 214 registrations and 196 attending first year students across its offerings in this form. The latest iteration from September 2017, the focus in this paper, saw 41 registrations and 38 attending students (36 respondents, n=36). Of these students, there was 27% female enrolment. This indicates above average engagement with female students when reflecting on the national and university figures for mechanical engineering enrolment which are classically 7% and 14% respectively.

Understanding Mechanical Engineering

When prompted about their knowledge prior to participating in the MEEA as being that they "didn't know anything about mechanical at all", "knew a little about mechanical", "knew a bit about mechanical but was still unsure" or "knew and understood mechanical", 79% of respondents identified that ***they knew little about mechanical engineering prior to attending to the session***. 97% of participants indicated that participating in the ***MEEA improved their understanding of mechanical engineering*** to some extent, with 45% of responses indicating that it "very much" improved their understanding when provided with the options of "very much", "slightly better", "still not sure" and "have no idea". As a majority of students indicated that they knew only a little about mechanical engineering before attending the session, it reflects the importance of making a concerted effort to engage and educate students on the opportunities within each discipline. Furthermore, due to the increase in understanding of mechanical engineering seen, it can be said that engagement activities may be one avenue to assist students with gaining insight into a discipline's nuances.

Engagement with Mechanical Engineering

69% of respondents indicated that prior to attending the MEEA that mechanical engineering was "one of" the streams they were considering with 22% documenting that they were "a little" interested in mechanical engineering. This was when presented with the options "I wasn't interested", "I was a little interested", "Mechanical was one option" and "I was definitely planning on choosing mechanical". ***No participant reported that their level of interest in mechanical engineering decreased as a direct outcome of participation in the MEEA*** when presented with the options of "I am less interested", "my interest has not increased or decreased", "I am a little more interested", "Mechanical is now an option that I am considering" and "I am now definitely planning on choosing mechanical". 33% of students reported being a "little more" interested in mechanical engineering while 44% identified that mechanical engineering is now an option they were considering for branch selection. As no student's interest in mechanical engineering regressed and some students reported an increase in interest, it demonstrates that there was no net harm caused by undertaking an engagement activity in this instance. This suggests that for an institution looking at engaging students with a discipline of engineering, engagement activities could be considered as a beneficial method to do this.

MEEA Activity Design

When considering the design of the session itself, 95% of students felt they had enough time to complete the tasks, 97% felt that the session was of a good length and 97% felt that the session was of appropriate difficulty. This was reported when students were prompted if they had enough time to complete tasks with the statements "Yes", "No, I would have preferred it to be shorter", "No, I would have preferred it to be a little longer" and "No, I would have preferred it to be much longer", if the session was of appropriate length with statements "Yes", "I would have preferred it to be shorter" and "I would have preferred it to be longer" as well as if the session was of appropriate difficulty with statements "Yes", "No, it was too easy" and "No, it was too complex". The students who participated in this particular session felt that it had been designed appropriately. This was of importance given the activity difficulty being set slightly above expected competency levels. It could be suggested that students in this

cohort responded well to the challenge in the structured environment created. ***All students indicated that they were likely to recommend the MEEA,*** demonstrating the overall satisfaction with the scholarship of learning and teaching choices implemented in this context and instance. Taking the Definitely Not to Extremely Likely 5-point Likert scale where 0 represents definitely not and 5 represents extremely likely, the average score for the likelihood of recommending the session was 4.3 ± 0.7.

Written Feedback

Written feedback demonstrated students enjoyed the problem-solving elements and that the ***best aspect of the MEEA was the hands-on nature of the tasks***. Given students have ample opportunities during their studies in first year to partake in hands on activities by way of three major design projects, one can suggest that this is not merely through lack of opportunity to partake in such activities from which this is being derived. This also bodes well as the mechanical engineering degree incorporates many hands-on projects and experiments. Similarly, students noted that they appreciated the introduction to the mechanical engineering course and the "down to earth" and friendly nature of the demonstrators. These comments reflect many of the scholarship of learning and teaching choices made including the emphasis on inquiry based learning and the ambiance. Furthermore, it emphasises the important of selecting the right people for the task as the demonstrators were often noted as a key influencer on the student experience.

Conclusion

The MEEA attracted a higher incidence of female students than expected, suggesting that careful design and marketing can in some regards, overcome stereotypes presented about an engineering discipline. The MEEA improved students understanding of mechanical engineering significantly, suggesting that scholarship of learning and teaching recommendations for learning and engagement at an academic level are transferable into the engagement space. This is further supported by student respondents indicating that the MEEA was enjoyable and that the best aspects were the hands-on nature of the task and the problem-solving elements, both direct reflections of the recommendations considered.

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