What is engineering and an engineer?

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Abstract
This young person-focused project aimed to identify students’ perceptions and understanding of the concept of ‘engineering’ and an ‘engineer’. The project looked to address the ‘mismatch’ between what young people think engineering is and the reality, at the same time showcasing ways for school teachers to more accurately inform their students about the true nature of engineering in order to encourage more young people to study engineering in the future.

The aim was to collect the views of young people about engineering as a subject, career choice and discipline. It was planned to bring school pupils to the university for a ‘taster day’ where they could work with our staff and undergraduates and experience university level engineering facilities first-hand. The students would then be interviewed again to see if their original assumptions had changed. In addition to providing the young people with greater appreciation and excitement about the subject of engineering, it was hoped to use their feedback and the insight gained into their thinking to plan future activities more effectively.

Keywords: widening participation, outreach, perceptions of engineering

Background
European research organisations recognise the importance of science communication. We need potential scientific minds to address the ‘grand challenges’ the world faces: “The importance of communicating science to the general public cannot be overestimated. Science cannot live isolated from society” (Potocnik, quoted in the Times Higher Education, 2004).

The UK needs growing numbers of future engineers (National Academy of Engineering, 2008). We need new perceptions and thinking from non-traditional students. Globally controversial decisions are being made for a society which doesn’t understand the concepts that underpin scientific and technological developments.

Outreach activities inform and inspire; however, young people often attend these with a misunderstanding of the fundamental nature of university and its disciplines (e.g. engineering). This misunderstanding is not restricted to young people, but held widely within society by teachers and even some careers staff (Marshall et al., 2007).

It was expected that the students would identify stereotypical engineering jobs such as buildings, bridges, cars etc., as has been seen in some previous research (Cunningham et al., 2005); however, they would not grasp how deeply engineering impacted on their everyday lives. The project planned to impress this upon them and also challenge the idea of ‘oil and overalls’, which is why we specifically wanted to work with an all-girls school, as they are under-represented in the engineering department.
Rationale

By listening to students’ voices, before they engage with engineering academics, examples of perceptions and misunderstandings can be collected, with the aim of producing a methodology which directly addresses them by increasing the understanding of teachers who will then become Change Agents within schools.

The project was undertaken following feedback from our colleagues in the engineering department. They are involved in local summer schools that involve Year 10 students attending two-hour subject taster sessions. These have always proven very popular in the recruitment stage but, when questioned during the session, the young people did not have clear reasons why they picked the session beyond “it sounded good”. They also have only limited knowledge of the career options to which engineering leads and the subject choices they need to make at school level (i.e. taking sciences).

The engineering department is very proactive in widening participation. However, engineering is also a very competitive subject area and many of our widening participation students attend poorly performing schools which may mean that they do not achieve the grades needed. This project aimed to gain information that can be fed back and lead to changes in information and attitudes towards STEM early enough for the students to take positive steps towards this area.

### Table 1. Background data for schools targeted

<table>
<thead>
<tr>
<th>School name</th>
<th>%A*-C (inc Maths and English) 2010 data</th>
<th>% of pupils living in the 13,000 most deprived wards nationally</th>
<th>% FSM (free school meals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hillside High School</td>
<td>41</td>
<td>98</td>
<td>32.8</td>
</tr>
<tr>
<td>St George of England High School</td>
<td>41</td>
<td>97</td>
<td>40.8</td>
</tr>
<tr>
<td>Notre Dame Catholic College</td>
<td>46</td>
<td>99</td>
<td>44.5</td>
</tr>
</tbody>
</table>

The aim was to develop a model which could be used by other universities to challenge this problem of misinformation in future students who could work in globally important fields: “Long-term, there is doubt over the pipeline of young talent into engineering from schools, onto university engineering courses, and subsequently into engineering firms” (Spinks et al., 2006).

The approach

The project team aimed to work with Year 10 students from three different types of local schools: an engineering specialist school, a school with a large widening participation cohort and an all-girls school. It was thought that this choice of schools would provide us with young people from backgrounds traditionally under-represented on engineering degree courses, as well as students who should perhaps have had access to different guidance and information (engineering specialist school vs ‘standard’ school). As previously mentioned, the schools we targeted had a high proportion of free school meals and socio-economic deprivation. By comparison, the University of Liverpool engineering department student intake for 2010/11 was only 19.8% NS-SEC 4-7, the government indicator for low family income (Office for National Statistics, n.d.).

Three local schools were approached that each matched one of the three criteria listed above. They were all eager to be involved. The schools were asked to identify 15-20 students each for the project as we felt that a total of 60 for the visit day would be an impressive but manageable size and would give more representative data for the ‘post-intervention’ questionnaires. In hindsight, this was potentially a limitation as the criteria for the schools selection should have been more robust. The project was about ‘average’ students’ views; however, the students who took part may have had to express an interest, indicating a prior attraction to engineering. The only solution would have been to use whole year groups, which would have resulted in unmanageable group sizes.
As well as speaking to the target schools, we also held discussions with our engineering department about the content of the visit days and what activities would be best for the young people to be involved in to have maximum impact. We settled on two separate, hands-on activities. The first was a bridge-building activity using spaghetti that motivated the young people to think about forces and the physics involved. The second session involved transporting an egg across the classroom suspended from a helium balloon. This involved weighing and measuring to judge the size of the balloon needed. Whilst these were delivered with fun in mind, they both also included the basics for some of the real world problems engineers have to deal with.

As the university facilities were so advanced and different to those the young people would have experienced in school, we felt it was important to include a full tour of the facilities to impress on the students the size and variety of the subject area. We also felt it was important for the young people to meet and interact with some engineering undergraduates who were closer to their own age and able to act as role models for them. These undergraduates comprised a mixture of genders and ethnic groups to ensure that diversity was fully represented.

The welcome talk was given by one of our senior academic staff who explained the purpose of the day and also set the scene by asking the young people to think about engineering in their everyday lives. This was done, very simply and effectively, by asking the young people what they had had for breakfast that morning and then considering all of the different ways engineering had affected that meal (crop harvesting, refrigerated lorries, metalwork to make the spoons, etc.).

A questionnaire (see Appendix 1) was filled out by the young people on first meeting us. We then attempted to bring all the schools to the university on the same day to work with the engineering staff and undergraduates and take part in the activities. Sadly, due to internal problems within the schools, only one school out of three was able to attend the visit day on campus and this meant the sample size was smaller than we had envisaged. The activities were run as planned but the large size class we hoped to create was missing.

After the activity day we visited the students who had attended to capture their new thoughts and impressions about engineering. We hoped to see a greater understanding of the day-to-day involvement engineering has in their lives.

The activity day took place in June, when schools and the university have few timetabling and exam commitments. As two schools had been unable to attend, a further attempt was made to arrange a second visit (a repeat of the first) in September, once the school holidays had finished. Due to timetable issues in the schools and the new university intake we were unable to find a common date, despite three months of correspondence. We felt that this highlighted a fundamental issue when working on this type of project: that all sides will have external pressures that can hamper smooth running.

It was decided to access the students before and after their interaction with the university to see if there was a change in their knowledge and attitude towards engineering. We also used the ‘pre-intervention’ data as a baseline to see what the students already felt about engineering as a discipline.

The evaluation form was created with the help of the Monitoring and Evaluation Officer for Aimhigher Greater Merseyside and was designed to capture the students’ thoughts and feelings in a replicable way. The ‘post-intervention’ evaluation form was very similar to the ‘pre-intervention’ form so that direct comparisons could be made between the two. For the most part, the questions were simply tick boxes; however, we did have some questions that allowed the young people to give fuller and more varied answers. Many of these were one-word answers, rather than detailed sentences, but they did allow for individualism in the responses (for instance, over 30 everyday objects were identified as being produced through the work of an engineer).

**Evaluation**

Due to the low number of students that took part in the full programme the results are limited. We had planned to compare the students’ feedback after the event with the information gathered
before. As the same students would be working with us this would give a clear comparison. The ‘pre-intervention’ questionnaire was also useful for collecting the impressions of the average 14 year-old of engineering as a discipline.

As mentioned above, the questionnaire was designed with help from the Monitoring and Evaluation Officer of Aimhigher Greater Merseyside. We wanted to get background from the students (such as favourite subject, family history, etc.), as well as their impressions of science/engineering and some insight into their knowledge of exactly what these are and how they impact on their lives.

One of our initial impressions was that the group knew more about the subject area than expected. This project had been devised because we found that students attending summer school sessions did not have much knowledge about engineering, which lessened the impact of the sessions. It was predicted that the young people involved in this project would have a basic understanding of engineering; however, this would be mainly through TV and family. To an extent this is true, as the most popular image of an engineer was in overalls, goggles and with ‘crazy hair’. The most common perception of where engineers worked was in a garage, and ‘mechanic’ was specifically mentioned on the ‘pre-intervention’ questionnaires. This was expected; however, there were also students who mentioned turbines and bridges, which showed a more comprehensive understanding. This links to the point raised in ‘The approach’ above: that we may have been working with students who had already considered engineering as a career, as opposed to randomly selected Year 10 students.

One concept that was noticeable by its absence was product design. The students only talked about engineers building or fixing things (all hands-on and practical). In the ‘post-intervention’ questionnaire, students mentioned engineers ‘developing’, which shows that their impressions of engineering had changed and they had come away with new ideas about the role. The students also mentioned a lot more everyday items that have come about through the work of engineers, which we found reassuring.

A positive aspect was that the majority of the students we interviewed realised how important education was to becoming an engineer and knew that university was an important stepping stone to this career. Before the event, five out of 11 said they “didn’t know” if you needed to attend university. After the event they had all made a decision, most saying that university was important.

One aspect we did not consider was that some students may be absent from school when we returned to complete the ‘post-intervention’ questionnaire. This did occur and so, at a glance, the figures expressed in Question 4 seem to show that the students are less likely to go to university, when in fact there were actually less interviewed because of sickness.

Discussion, summary

The success of the project was limited due to poor attendance at the on-campus activities. The students that did attend not only enjoyed the day and left with a more positive view of university and engineering, but also gained more knowledge about engineering - a core aim of the project.

As previously mentioned, some of the ‘pre-intervention’ questionnaires indicated a greater knowledge of engineering than we expected. Although some of the questions were designed to find out whether the young people were already thinking of it as a career, any future projects could tackle this topic head-on by specifically asking if they were considering this career option and, if the answer was yes, identifying influences (e.g. family, television, school staff etc.).

It was interesting to note that more students identified that engineers work in a variety of places and professions rather than simply in factories and garages on the ‘post-intervention’ questionnaire. This is a discussion point that seems to have come across to the whole group and we assume was identified while the students were speaking to the members of staff and the undergraduates.

The all-girls school was one of the schools unable to attend and so the conclusions we can draw from gender differences are limited. This is something that could be rectified in any further work, as
there is evidence that females are under-represented in engineering worldwide (Vest, 2005; Excell, 2011).

Our major difficulty with the evaluation is trying to draw conclusions from the limited responses we have available to us. We can be confident that the students who attended the university learnt more about engineering and what this career path involves; however, we cannot be certain that these are the feelings of an entire year group because of the numbers involved.

For another project of this type, one of the key changes we would recommend would be to have the dates set from the very first meeting with the schools. Trying to be flexible around dates with three schools can be very challenging and trying to accommodate them can lead to lots of changing and ultimately to key events not happening. A better idea would be to have dates agreed with the engineering department and then give these to the schools; if they cannot commit then move on to an alternative school that also meets the specified criteria. If the original number of schools had been larger this would also have helped, as the impact on lack of attendance would have been reduced.

Further development

Our engineering department has worked closely with us in the past, delivering one-off taster sessions at larger events. These sessions were always well-received in the short term; however, the feeling was that the long term effects were unknown, which is why we originally bid for this project.

Whilst we cannot continue to work with the same students in the future, it has been useful to strengthen links with local schools, and university staff have viewed the events as good experience of working with younger students. Depending on funding and other internal commitments, we are hopeful that further pre-16 outreach work can take place.

If this proves to be the case, we could look to identify the preconceptions of a wider audience, perhaps analysing these results before we plan the next stage of the activity so as to be more informed as to the students’ mindset.

References


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